THE OHIO JOURNAL OF SCIENCE

VOLUME XXXI — 1931

HERBERT OSBORN, Editor

PUBLISHED AT COLUMBUS, OHIO, BY THE

OHIO STATE UNIVERSITY

and the

OHIO ACADEMY OF SCIENCE

TABLE OF CONTENTS

VOLUME XXXI.

NUMBER 1—JANUARY.

PAGE

Long-Continued Determinative Orthogenetic Series. Studies in Determinate Evolution, IV ..... *John H. Schaffner* 1

The Scioto Marshes of Ohio: A Study in the Geography of Onion Culture, *Carl Dudley Varvel* 17

The Native Iris of Ohio and Bordering Territory ..... *A. E. Waller* 29

Ohio Mosses, Hypnales ..... *Nellie F. Henderson* 44

NUMBER 2—MARCH.

Principles of Plant Taxonomy, X ..... *John H. Schaffner* 77

Habits of the Short-Tailed Shrew, *Blarina brevicauda* (Say), *W. J. Hamilton, Jr.* 97

LeConte's Epitome of Evolution ..... *George J. Dudycha* 107

Observations on *Cercaria gorgonocephala* Ward ..... *Stephen R. Williams* 115

A Sectioning Chamber ..... *Stephen R. Williams* 118

Diurnal Variations in the Amount of Dissolved Oxygen, Alkalinity, and Free Ammonia in Certain Fish Ponds at Fairport, (Iowa) ..... *A. H. Wiebe* 120

A New Crustacean of the Family Aglaspidæ from the Upper Mississippi Valley ..... *William A. P. Graham* 127

NUMBER 3—MAY.

Present Tendencies in the Philosophy of Biological Evolution, *George J. Dudycha* 129

The Alimentary Canal of *Meracantha contracta* Beauv. (Tenebrionidæ), *Warren C. Miller* 143

The Grass Balds of the Great Smoky Mountains of Tennessee and North Carolina ..... *W. H. Camp* 157

A Preliminary Pollen Analysis of the East McCulloch Peat Bed, *George H. Lane* 165

"Bird Sanctuary" Suggestions ..... *S. Prentiss Baldwin* 172

Modern Buildings and the Termite Problem ..... *Dwight M. DeLong* 177

Hive Temperatures for Each Hour of a Day ..... *W. E. Dunham* 181

The Hypsometric Map Versus the Projected Profile Method in Portraying and Determining Erosion Surfaces ..... *Karl Ver Steeg* 189

Philip Rosemand Lowry, M. Sc ..... *Herbert Osborn* 191

Book Reviews ..... *H. O.* 192

NUMBER 4—JULY.

Proceedings of the Forty-first Annual Meeting of the Ohio Academy of Science ..... *W. H. Alexander* 193

Additions to the Catalog of Ohio Vascular Plants for 1930 .. *John H. Schaffner* 299

NUMBER 5—SEPTEMBER

PAGE

The Development of Drainage Systems and the Dynamic Cycle, *Waldo S. Glock* 309

The Epibranchial Ganglion of the Glosso-Pharyngeal Nerve in *Amblystoma jeffersonianum*.....*F. L. Landacre* 335

Characteristic Examples of Accumulative Progressive Evolutionary Movement Studies in Determinate Evolution, V.....*John H. Schaffner* 346

Drainage Changes in the Vicinity of Loudonville, Ohio....*Karl Ver Steeg* 368

The Genus Agallia—External Characters Used to Distinguish the Species Injuring Economic Crops.....*Dwight M. DeLong and Ralph H. Davidson* 377

The Alimentary Canal of *Asaphes memnonius* Hbst.....*John T. Bigham* 386

The Alimentary Canal of *Criocerus asparagi* Linn.....*Ralph Howard Davidson* 396

The Alimentary Canal of *Sphaeroderus nitidicollis* Chev. var. *Schaumi* Chd. (Coleoptera).....*Paul Everett Schaefer* 406

Bisporangiate Inflorescences in Pseudotsuga.....*E. W. Littlefield* 416

Ohio Academy of Science—Author's Abstracts..... 418

NUMBER 6—NOVEMBER.

Glaciation of Northwestern Holmes County, Ohio.....*Geo. W. White* 429

A List of Parasitic Copepods and Their Fish Hosts From Lake Erie, *Wilbur M. Tidd* 453

New and Interesting Plankton Algæ from Lake Erie, *Lewis H. Tiffany and Elbert H. Ahlstrom* 455

Notropis volucellus wickliffi, a New Sub-species of Cyprinid Fish from the Ohio and Upper Mississippi Rivers.....*Milton B. Trautman* 468

A Quantitative Net-plankton Survey of East and West Reservoirs, Near Akron, Ohio.....*Walter C. Kraatz* 475

Fossil Footprints from the Pennsylvanian of Ohio.....*Robert H. Mitchell* 501

Additional Mallophaga from Ohio Birds.....*Robert M. Geist* 505

Obituaries:

James Stewart Hine.....*C. H. Kennedy* 510

Charles Dury.....*Annette F. Braun* 512

Editorial Note.....*H. O.* 514

Index to Volume XXXI..... 515

THE OHIO JOURNAL OF SCIENCE

VOL. XXXI JANUARY, 1931 No. 1

LONG-CONTINUED DETERMINATIVE ORTHOGENETIC SERIES.*

STUDIES IN DETERMINATE EVOLUTION, IV.

JOHN H. SCHAFFNER.

There are many evolutionary movements which continue consistently and progressively from the very beginning to the highest possible level, right through a series of the fundamental subkingdoms and often in a number of distinct lines. These determinative movements show that the evolution is not primarily dependent on any special kind of environment nor on any peculiar type of organization. All special teleological notions are immediately dissipated when one once clearly grasps the real import of such consistent progressions.

1. EVOLUTION OF THE PARASITIC INTER-RELATION OF THE TWO GENERATIONS IN THE ALTERNATION OF GENERATIONS CYCLE.

In the lowest plants with an alternation of haploid and diploid generations, all individuals carry on an independent existence. There is no parasitic inter-relation of one generation on another. Such a condition is present in the brown alga, Dictyota. But certain red algæ show the first stage of a parasitic sporophyte in that the fertilized egg or zygote is not discharged or separated from the parent plant but germinates by budding and produces a number of diploid carpospores. This developing zygote of numerous diploid cells represents the first step in a parasitic relation which becomes very prominent in the higher plants. The carpospores are discharged and each one develops an independent sporophyte. Such a condition is represented by the well-known Polysiphonia. In Batrachospermum the zygote develops into a vegetative,

*Papers from the Department of Botany, The Ohio State University, No. 244.

branching sporocarp of considerable size, the carpospores being developed at the ends of the branches.

The complete parasitism of the sporophyte is attained in the living bryophytes. The lowest stage is represented by Riccia where, after a parasitic vegetative development, the entire sporophyte except the epidermal layer is transformed by reduction divisions into spores. As one passes through the bryophytes one meets successively higher types of sporophytes, each stage representing a progression toward partial independence of the sporophyte which, however, never loses its parasitism in any phase of its life.

The decided advance is attained on the level of the lowest living pteridophytes where the parasitism of the sporophyte is restricted to the juvenile phase, the individual gradually growing into an independent individual. All of the pteridophytes, both homosporous and heterosporous have the two-phased condition of the sporophyte. Step by step the importance of the independent phase is advanced until in the heterosporous pteridophytes, the independent mature sporophyte not only nourishes itself but provides a complete supply of food in the spore both for the gametophyte and for the juvenile life of the following sporophyte which is thus nourished through the mother gametophyte on food provided by the sporophyte grandparent.

In the next stage of advancement the gametophyte becomes completely parasitic on the sporophyte, and while the following sporophyte is passing through its parasitic phase it is nourished by its mother gametophyte with food furnished directly by the grandparent sporophyte. This is a decidedly progressive improvement over the previous method of furnishing a supply of nourishment to the dependent gametophyte and its offspring.

In this state the parasitic relation between the two generations has reached its determinate limit. In the angiosperms a further complication is added in a new evolutionary movement which supplies a xeniophyte, which from one point of view is simply a further elaboration of the parasitic inter-relations of the generations. The gametophyte is enormously reduced and the embryo is surrounded by the xeniophyte which functions as nurse to the sporophyte especially during the sprouting period. This development is, however, not because of any compelling necessity, since very many angiosperms have very little endosperm and the food is stored directly in the embryonic sporophyte.

Now this whole movement constitutes a most remarkable progression which keeps a straight course through all the numerous advancing lines of higher plants, through all the diversity of environments. It continues in a progressive march until the goal is reach. If we wish to see an altruistic ending, it is plainly on the surface because this progressive movement has not only taken care of the reduced and helpless gametophyte but it has also taken the embryo sporophyte and continued it in the most advantageous condition in relation to the struggle with the environment. In these respects the highest plants have evolved in the same way as the highest animals, including mammals and birds, and some reptiles, insects, spiders, and fishes in which the most remarkable evolution in the care for the young has taken place, which care is entirely absent in the lower animals as it is in the lower plants. This long-continued evolutionary movement in the dependent relationships between the two generations is, therefore, remarkably consistently progressive, orthogenetic, perfective, and determinative. It has been carried to the limit.

A consideration of the preceding series will show how untenable are the claims that parasitism or dependence leads to degeneration or reduction. Just the opposite came about. The independent generation passed through a reduction series and at last became parasitic only after the reduction had reached an extreme degree of minuteness. The completely parasitic generation, altho it never lost its juvenile parasitism, evolved step by step attaining independence in the mature condition until we have a giant Sequoia 30 ft. in diameter, 300 ft. in height, and 3000 years of age.

2. The Shifting of the Reproductive Process From the Center of the Stem or Bud to the Outside.

The Meta-thallophyta present a very interesting orthogenetic evolutionary series in respect to the shifting of the reproductive activity of the sporophyte. In Riccia and Ricciocarpus, the lowest forms, the entire center of the stem or body is involved in the production of spores. In the higher liverworts, not only is the lower part of the sporophyte sterilized but the first indication of a movement of the reproductive tissues toward the outside is in evidence by the development of sterile cells or elaters in the interior of the sporangium among

the sporogenous cells. In the true mosses and horned liverworts a completely vegetative columella is differentiated, the sporogenous tissue forming a cylinder within the cortical layer. Now in the evolution from a bryophyte condition to the condition of the living vascular plants, before lateral leaf appendages appeared, the sporogenous tissue must have been developed in the outer parts of the stem just below the epidermis, and even after leaf appendages were present sporangia might still be produced from the external stem tissues or at least in the leaf axils, as in some lycopods. Apparently in such primitive vascular plants like the fossil Psilophyton the sporangia were still developed at the tips of stems as in the higher living bryophytes. But in the lines which are represented by living pteridophytes, the reproductive center was shifted entirely to the lateral appendages and sporangia are borne on the leaves from the ferns on up. The shifting of the sporogenous center from the stem axis or terminal bud to a lateral appendage was one of the main factors in the evolution of indeterminate sporophytes, although with the introduction of a branching system, either dichotomous or monopodial, indeterminateness could be attained for the sporophyte as a whole even though some buds still were destroyed through the development of terminal cauline sporangia as in Psilophyton.

The movement of the reproductive process toward the periphery of the plant does not involve the epidermal layers in most of the higher evolutionary lines. In one series, however, the leptosporangiate ferns, the movement attained the extreme limit in that the sporangia are not only produced on the stem appendages or leaves but from the very epidermal layer of cells itself. Thus the orthogenetic movement has reached the determinate limit in these plants. In the lowest forms, like Riccia, the entire system except the epidermis is involved in spore reproduction, while in the leptosporangiate ferns the epidermis alone is involved in the reproductive process all the remaining tissue systems continuing permanently in the vegetative state. The movement has progressed from one extreme to the other.

In all other higher plants, however, the eusporangiate condition is normally maintained and the epidermis does not take part in spore production. The sporogenous cell is normally a sub-epidermal cell of the first layer from which the sporocytes finally develop. The reproductive process, however, continues

in its centrifugal movement with the evolution of a monopodial branching system and determinate floral axes. The first flowers of the living seed plants are terminal on the main axis, as in Cycas, Dioon, etc. The continuation of vegetative growth is then from an axillary bud beside the cone. But in plants like Macrozamia and its relatives sporophylls appear only on secondary axes, both carpellate and staminate cones being developed in the axils of foliage leaves. With a further evolution of the branching system the reproductive process is shifted out still farther so that the sporophylls appear only on tertiary, quaternary or still more extreme axes, as in Araucaria, various palms, yuccas, etc. With the introduction of vegetative and short-life evolutionary processes in the higher plants, the reproductive process may undergo a recession and may finally appear again on appendages of the primary axis. But this is a new evolutionary movement changing the former gradients and may in itself show an orthogenetic progression.

3. Progressive Recession in the Development of the Archegonium.

In the liverworts and mosses the entire archegonium is differentiated from a papillar outgrowth extending above the general surface of the plant. From this position there is a consistent retrogression as one goes upwards through the higher plants until the entire structure is developed internally. This movement goes parallel with the progressive reduction of the gametophyte but is not necessarily dependent on the movement. In the Anthocerotæ, which have well-developed gametophytes, the differentiation of the entire venter with the egg and ventral canal cell takes place in the internal tissues below the general level of the surface and only the neck is differentiated from the papillar outgrowth. Here then, as in so many evolutionary movements, the process of differentiation gains on the ontogenetic development and thus the initiation of the given differentiation process takes place in successively earlier and earlier stages of the ontogeny. In this case the movement is also in agreement with the evolutionary reduction of the gametophyte but is not to be interpreted as being primarily due to this cause, since exactly similar movements take place in other morphological systems where no reduction of the individual is in evidence.

In the homosporous pteridophytes, the venter always has an internal development and the neck of the archegonium is in general much shorter than in the bryophytes. In the heterosporous pteridophytes the neck consists of but a few cells extending beyond the general surface, while in the gymnosperms there is practically no papillar outgrowth whatever, the few remaining neck cells being on a level with the general surface of the body or nearly so and range from eight down to two, except in the Gneteæ. In this highest class of gymnosperms there may be three or more tiers of cells but they do not project above the surface and are not really a true neck but a new structure, something like a tapetal layer. In the angiosperms also the archegonium or egg apparatus is reduced to the extreme limit. Either there is nothing left of the ovary except the egg and ventral canal cell (polar nucleus) or the two synergids represent the last vestige of a neck. In the lower forms there is a long row of neck canal cells and these are gradually reduced to zero, there being but one in the heterosporous ferns and none in the gymnosperms. The evolution of the archegonium thus again shows a consistent orthogenetic, progressive movement through the last five subkingdoms of plants. The general movement has not been disturbed by any of the great segregative movements, resulting in phyla and classes, which have taken place in the evolution of the Meta-thallophyta.

4. The Five-fold Parallelism of the Orthogenetic Progression in the Time of Sex Determination.

In the lower multicellular algæ the sexual states are developed only in the very last cells of the ontogeny, the male and female gametes often being sister cells. From this condition, as one ascends the evolutionary ladder of the sexual plants, the time of sex determination with a dimorphism of sexual states and structures is projected backwards step by step in the ontogeny until the extreme is reached and the sex is determined in the egg, the entire individual being then, of course, normally in a single sexual state. This orthogenetic progression is in evidence both in various series of haploid green algæ and in diploid brown algæ.

In the Meta-thallophyta a similar movement takes place in the evolution of the gametophytes of both the bryophytes and homosporous pteridophytes. The lowest stage present is the

synoicous hermaphroditic condition where sex is determined in the incipient gametangia. From this condition the progression leads through to the paroicous and various degrees of the autoicous condition until in the highest forms unisexuality is attained in numerous lines. The higher plants have all attained the extreme limit, namely all the heterosporous pteridophytes, gymnosperms, and angiosperms. The movement to unsexuality has a definite limit in the spore from which the gametophyte comes. But a new evolutionary series is still possible in the shifting of the time of sex determination backward into the sporophyte itself. This condition initiates a new orthogenetic movement which travels through the ontogeny backwards until the zygote is reached completing the fourth parallel evolutionary movement in respect to time of sex determination.

In the lowest type of heterosporous sporophytes the sexual state is determined in the incipient sporangia and from this condition the time of determination progresses backward through forms with monosporangiate sori, monosporangiate sporophylls with one or the other sexual state determined in the incept of the organ, through the normal bisporangiate flower with maleness determined in the flower bud first and then femaleness, through a series of more and more extreme monecious types, until the determinate limit is reached in the normal diecious condition. The progressive series from bisporangiate flowers to dieciousness is repeated many times in the seed plants including both gymnosperms and angiosperms.

In the higher fungi a truly remarkable sexual condition is established in the evolution of an incomplete primary sexual state. In some of the highest Phycomycetæ as well as in a few of the lowest Ascomycetæ the male and female nuclei, after copulation of the cells, do not immediately fuse but sometimes there is a long delay in this process. This delay is to be attributed to an incomplete primary sexualization for the time being of the nuclei involved. In some of the lower Ascomycetæ vegetative divisions take place before the nuclei finally pass to the complete primary sexual states. These cell divisions are conjugate divisions which occur in such a way that each daughter cell normally receives a pair of the conjugate nuclei. The time of incomplete primary sex determination soon begins an evolutionary retrogression through the ontogeny of the fungus in the same general manner as has been described above for the time of secondary sexual state determ-

inations in the gametophyte and sporophyte series. At the extreme evolutionary limit, as in some smuts and in some of the Gasteromycetæ, the determination is shifted back to the basidiospores themselves which thus copulate and the binucleate or conjugate phase is established in the mycelium at the very beginning of its development. In the extreme homothallic species the first two sister nuclei which arise from the basidiospore nucleus become sexualized with the incomplete primary sexual states and act as a pair of conjugate nuclei. Thus not only is the entire mycelium normally made up of binucleate cells but the process of external copulation at the initial point is entirely eliminated. Nothing like an external conjugation remains in the system outside of the process which takes place in the formation of clamp connections.

In respect to the time of sex determination, there are thus five distinct orthogenetic evolutions or progressions which have evolved independently in five fundamentally different plant constitutions.

1. The movement in the green algae with a simple haploid sexual cycle.
2. The movement in the brown algae with a simple diploid sexual cycle.
3. The movement in the higher fungi in the time of determination of incomplete primary sexual states.
4. The movement in the haploid gametophyte of homosporous plants with typical antithetic alternation of generations.
5. The movement in the diploid sporophyte of heterosporous plants with typical antithetic alternation of generations.

One cannot help but be impressed with this remarkable five-fold parallelism. It is a truly marvelous condition and shows conclusively that fundamental evolutionary movements are not dependent on accidents of morphological differences nor on accidents of physiological and ecological relations. The evolutionary principle lies deep down in the fundamental nature of the living substance itself.

5. Orthogenetic Series Representing Increase of Difference or Divergence of Character Between Sporophyll and Foliage Leaf.

In the specialization of the sporophyll, there is a remarkably uniform progression from the lowest stage where there is no apparent difference until the most extreme divergences are reached at the ends of the various phyla. Among the many series available only a few which can be easily studied will be considered. Many of the lower leptosporangiate ferns, in

which the sporophylls are not on a determinate axis, show no divergence whatever from the foliage leaf while among the higher species a greater and greater degree of difference is developed. In such extreme species as *Onoclea sensibilis* there is a decided dimorphism. The same movement is seen in the carpels of the Cycadales, in passing from the low forms, like *Cycas revoluta* to species of Zamia. In the conifers, the lower groups and species, like Araucaria, have very leaf-like sporophylls while the higher groups and species, like Juniperus, have blue or reddish fleshy cones in which the carpels differ enormously from the foliage leaves. The same serial movement is repeated in the angiosperms. Some Magnolias have rather prominent foliaceous tips. These carpels are probably the most leaf-like of any in the angiosperms. When one proceeds to the highest types there is the merest vestige of a correspondence with the leaf. The divergence is extreme. Thus there is plainly a continuous, progressive movement in the complexity of reactions in the leaf, proceeding from a reaction that shows no difference whatever between sporophyll and foliage leaf except for the presence of sporangia, to the condition in which the differentiation reactions are so extreme that practically all correspondence is obliterated. Again these movements show no relation to peculiarity of morphological or physiological conditions nor to any peculiarity of environment. The movements simply plough their way upward from the bottom to the top.

6. Orthogenetic Evolution of Determinateness in the Floral Axis.

The lowest living pteridophytes have only indeterminate axes, the bud continuing vegetative growth after the production of sporophylls. Flowers, or determinate reproductive shoots, are evolved at various levels in the several phyla. In the Lepidophyta and Calamophyta, flowers appear in the homosporous level. In the fern series no flowers apparently evolved in either the homosporous or heterosporous levels until the seed condition was established. All the living angiosperms and all the living gymnosperms have flowers except the carpellate plants of Cycas and the single species of Ginkgo, including both staminate and carpellate plants. We see then that the flower evolved independently in several lines and that some

groups attained a high level without acquiring the determinate potentiality. The evolution is dependent neither on a definite stage of advancement nor on any particular morphological or physiological acquirement impelling to its appearance. Nevertheless, in nearly all lines, the flower does appear before the end of the series is reached. The first appearance of the determinate property, on which floral development depends, is marked by a rather imperfect mode of action as well as by decided slowness of action in bringing about the stopping of growth. Thus lower flowers often proliferate, namely, continue to grow later as a vegetative shoot, as can be seen especially in various species of Lycopodium, Equisetum, Araucaria, Larix, and Rosa. Because of extreme fluctuation also of the time of determination the number of sporophylls varies greatly. From this condition the evolution of a greater definiteness and greater promptness of determination soon becomes evident as one ascends the ladder of general advancement. Thus the cones of the lower species of Equisetum fluctuate more widely than the more advanced species. In Selaginella, the lower species, like *S. rupestris* terminate the growth of the floral axis very tardily, the bud continuing to produce sporophylls for a very long period, while species belonging to the higher groups, like *S. kraussiana*, stop growth very promptly. In every flower-producing phylum, the same movement is clearly in evidence. In Cycads the lower species have cones with very large numbers of sporophylls while in the highest the numbers are much smaller. In the Strobilophyta the evolution of the flower passes to a very extreme limit of promptness in cessation of growth. In some araucarians, as in *Araucaria brasiliensis*, the staminate cone has about 1000 stamens. As one passes up the series to the more highly evolved types the number is reduced step by step until the limit is reached. *Araucaria cookii* has about 400 stamens on the cone, *Pinus strobus* about 200, *Podocarpus sp.* about 70, *Taxus canadensis* about 7, *Ephedra trifurca* 5, *Gnetum latifolium* 2, *Gnetum gnemonoides* 1. It is impossible for the determinate movement to proceed farther unless epigyny were introduced and this did not occur in the gymnosperms.

In the angiosperms exactly similar movements occur in various phyletic lines. Some of the lower monocotyls have more than 1500 sporophylls in a single flower and the fluctuation is very great. Among the various lines which attain the limit

with a single stamen or a single unilocular ovulary with 3, 2, or 1 stigmas, either with the hypogynous or epigynous condition, the following are characteristic. In the hypogynous Helobiæ, Naias has one stamen; in the eipgynous series Vallisneria has two, or one divided into two halves; in the Spadicifloræ some species have single stamens; among the grasses, some species of Andropogon have one stamen; in the epigynous Scitaminales Canna and other genera have half a functional stamen left; in all the higher orchids there is a single stamen.

The same conditions evolve many times in the dicotyls, although more commonly the limit is two stamens or rarely two half stamens as in Salvia. The most extreme determinateness appears in the higher types of epigyny, where, although the number of sporophylls may not necessarily be reduced to the extreme limit, the center of the flower bud or flower axis actually stops growing before any floral organs have developed. This is possible because the floral organs are lateral appendages and can be developed from the cortical tissue around the center even though the growth of the center has ceased. Thus the culmination in the main evolutionary movement of the flower has been attained. If the bud stops growing before the floral parts appear the possible limit has certainly been reached. No further evolution in the given direction is possible in passing from complete indeterminateness to the extreme of determinateness. This acquirement, through progressive degrees of greater and greater promptness in the process of determination, of the floral axis brings us face to face with the serious aspects of the fundamental nature of evolution. It brings into clear view the reality of the proposition heretofore made that evolution is perfective and essentially determinative. The entire evolutionary history of the flower in its main characteristics shows a universal, progressive orthogenetic, movement which makes its way through the conditions of environment to the very limit. The limit is essentially the same whether, through other evolutionary movements, the plant has in the meantime progressed under the water, or into the desert. When one studies the taxonomic series, one is profoundly impressed with the orderly forward movements of all fundamental evolutions. The persistent reduction of the floral axis is especially impressive since it can be observed in so many different and independent phyletic lines.

7. Evolution of the Lateral Bud System of Woody Plants.

The sporophytes of the liverworts and mosses have a single terminal growing bud. When this bud is destroyed through sporogenesis, the individual begins to die. In the Pteridophyta two types of branching systems are evolved, the dichotomous or bud-twinning system and the monopodial or lateral-bud system. In the main series, many ferns still have practically nothing except the single growing apex. Among the rhizome ferns, sporadic lateral buds and finally branches are usually produced. Now this origin of lateral axillary buds in the main series of higher plants forms another orthogenetic, accumulative movement which can be traced upwards with a fairly constant progression. Among some of the cycads, only a few sporadic branches are produced while in the more highly evolved stem of Ginkgo, along with the addition of an internodal potentiality, a double system is present. Part of the time the more primitive heredity is in operation in a bud when it develops a dwarf branch on which normally no axillary buds are organized, and part of the time the buds develop with the new internodal potentiality in activity when a functional lateral bud is organized in each leaf axil.

The evolution of lateral buds can be followed to good advantage in the conifers. In Araucaria the leaf axils of the main stem do not develop functional buds except at rhythmical intervals. After a zone of stem is developed without buds, suddenly a ring of functional buds appears which immediately produces a whorl or zone of lateral branches. These branches also show sporadic development of buds in their leaf axils. Thus the main stem develops comparatively few functional axillary buds. Passing upward toward the higher conifers, as in Abies and Picea, the rhythmical development of zones of axillary buds continues; but sporadically many axils develop functional buds and branches between the successive, rhythmically developed bud zones. In the lower pines, the succession of whorls of branches is much the same as in the araucarians, spruces, and firs, but all the leaf axils in between also develop functional buds which give rise to small, determinate dwarf branches. The same development of axillary buds and dwarf branches takes place on all the long branches. Thus in pine every leaf axil on the main shoot and long branches produces

functional buds except the winter bud scales. Presumably the winter or resting bud was evolved before the general bud-development-potentiality was introduced. The dwarf branches also produce no functional buds, thus recapitulating the more primitive condition as in Ginkgo. Now in the higher species of Pinus many of the buds between the successively developed whorls of main branches also grow out into main branches and so these higher types become much less symmetrical in form than the lower types. On the various advancing levels of other series, the movement is also toward the production of more and more functional buds, and commonly more branches, until the limit is reached with a functional bud in each leaf axil. Going up to the typical woody dicotyls, one finds a functional bud normally in every leaf axil produced on the entire tree excepting the axils of the scale leaves of the resting bud. The movement is thus carried out rather consistently and the progression is from sporophytes with a single terminal growing bud to more and more numerous axillary buds until the extreme is reached with every vegetative axil developing a bud. This movement when carried out without the interference of other potentialities which might inhibit the growth of buds into branches results then in the evolution of a more and more complex branching system, from no branches whatever to such species among the conifers as *Juniperus virginiana* and *J. barbadensis*, or among the dicotyls as *Ulmus americana* and *Fagus grandifolia*, where the branch and twig system attains enormous complexity. Of course, evolutionary movements may and do arise in the higher series which run counter to this developmental capacity and thus simplifications may appear in the plant body. These simplifications, however, do not indicate simplification of the fundamental hereditary potentiality of the cell but rather, in practically all cases, the simplification and reduction of structures are brought about by actual advancement in complexity of the hereditary potentiality or reaction system. One such interference is the movement toward shortening of the life of the individual down to an annual. In such cases then an annual individual, on rejuvenation and prolongation of growth activity, may develop a much more complicated branching system than usual.

8. Evolution of the Pollen-tube.

The pollen tube represents a new development brought in with the evolution of the seed habit in the higher plants. The pollen-tube, morphologically, simply represents the bulging out of the top cell of the antheridial wall in preparation for the discharge of the male cells. Since the general trend of the heterosporous pteridophytes is toward the evolution of parasitic gametophytes, it is easy to see how the tip cell of the vestigial antheridium could be involved in the acquisition of a parasitic habit. From fossil evidence it appears that in the first stages of seed evolution, the ovule or megasporangium broke open entirely, while the female gametophyte was growing as a parasite within, in much the same way as in the more primitive condition when the megaspores were discharged. The pollen-grains that happened to lodge in this break would thus come near to or in contact with the surface of the female gametophye and the sperms would be discharged into the open and finally find their way down through the exposed necks of the archegonia. As the parasitic habit was evolving, the pollen-tube partook of the parasitic nature. Now when the ovule progressed in accordance with its own evolutionary trend and the ovule finally failed to develop a complete break in the nucellus, the pollen-tube, through its parasitic property, was able to penetrate the small amount of tissue, being guided, no doubt, by a more or less definite sex-reaction, initiated in the female gametophyte below. Thus on penetrating through the tissue below the pollen chamber, the sperms were discharged into the depression into which the necks of the archegonia opened. This condition is present in our living cycads, as in *Cycas revoluta*. Now an orthogenetic movement is on the way, and as one passes up the various phyletic lines of seed plants, a more and more efficient pollen-tube is encountered until the parasitic growth attained is truly marvelous, both as to extent and rapidity of development. Such a complicated evolution as the origin and development of the pollen-tube, along with all the other remarkable advances in the evolution of the seed habit, is understandable on an orthogenetic progressive principle, while on any teleological basis of utility and advantage to the individual, the whole subject takes on a fantastic aspect.

In the highest species of the living Cycadophyta, *Ginkgo biloba*, the pollen-tube development is of the same general

nature as in the cycads. In all plants above this level, the pollentube always penetrates to some distance into the female gametophyte. In the conifers there is no pollen chamber, the last vestige of a dehiscing megasporangium being obliterated, so the parasitic development of the pollen-tube begins on the surface of the nucellus and grows down until it reaches the venter of the archegonium into which the nonmotile sperms are discharged. The parasitic nature of the pollen-tube has increased very greatly in the Angiosperms so that a very long development precedes the growth through the nucellus. The tube grows through the stigma and style, enters the micropyle, and, after penetrating the female gametophyte, discharges the two sperms. One of the most extreme developments is in Indian Corn, *Zea mays*, where the pollen-tube grows down the very great length of the silk in about 32 hours. The highest expression of the parasitic ability of the pollen-tube is probably met in such plants as various species of the Amentiferæ where the efficiency of the tube is so great that it is able to penetrate directly through the side of the ovule or through the chalazal region, as in Casuarina, Ulmus, etc. In this respect as in many others, the Amentiferæ represent a high stage of evolution and not a primitive condition as is implied in their common placement at the base of the taxonomic dicotyl series. The irrational taxonomy still commonly in vogue is one of the chief hindrances in the understanding of correct evolutionary movements. Some of the older arrangements would require the complete re-creation of the species or group before any evolution could even be postulated aside from the hap-hazard or anarchistic kind, for which witches and fairies alone could be responsible. In the evolution of the pollen-tube we have, therefore, another important, orthogenetic progressive series which keeps a definite forward march along with other progressive movements that have taken place in the seed plants.

9. Orthogenetic Advancement in the General Complexity of the Life of the Sporophyte.

Not only are there definite progressive movements in the various morphological systems of the individual but the life of the individual taken as a whole shows the same characteristic progression. In Riccia, the lowest type of liverworts, the entire life of the sporophyte is spent within the confines of the

archegonium venter. In Marchantia and other liverworts there is at first a period of internal development and then the outer end of the individual breaks through the venter and development continues to maturity with existence in the external world. In the higher mosses there is not only an external existence but a functioning phase of various important physiological processes, like photosynthesis and transpiration. In Anthoceros a long-continued growth activity is added, which is continued even after spore maturity has begun. In the homosporous pteridophytes the important indeterminate phase is added to the complexity of the life history. In the seed plants there is not only a double-phased existence, but a definite resting period with subsequent sprouting or re-awakening is added to the complexity of the life of the sporophyte. Thus it is evident that these general conditions of life also represent progressive accumulations, each potentiality or set of potentialities being added to the system thus far evolved. The evolutionary process is a duplicate in a general way of the ontogenetic process through which the individual is developed, with an important difference, however. For while the ontogeny is a progressive awakening to activity of the potentialities present in the cell, the phylogenetic or evolutionary process consists of the definite addition of new potentialities through which the orthogenetic series is unfolded. The higher sporophytes, therefore, have all of the processes and accidents of life which all the lower and intermediate forms possess collectively, namely, (1) internal development, (2) external development, (3) independent functioning, (4) functioning after reproduction, (5) two-phased life, (6) resting period between phases, and (7) re-awakening after rest, or sprouting.

THE SCIOTO MARSHES OF OHIO: A STUDY IN THE GEOGRAPHY OF ONION CULTURE.[1]

CARL DUDLEY VARVEL,
Ohio State University.

THE AREA AS A UNIT.

The Scioto Marsh, a bog soil province in the western part of Hardin County, is the largest of several such areas in the glaciated region of Ohio. The term "Marsh" is no longer used here in the technical sense, but is a "carry over" from the days before the area was drained. It extends over 16,000 acres[2] and is believed to be one of the largest continuous onion producing areas in North America. Here the growing onion characterizes the summer landscape. The subject of its culture is foremost in local conversation. Onion cultivation leads successively to a condition of distinct wealth or relative poverty. It motivates an interstate migration of interesting laborers and furnishes the raison d'etre of three settlements within the local region.

The greatest agricultural interest of most of the landowners is the onion. On an average about 3,500 acres of onions are harvested. In recent years the acreage has diminished largely as a result of several years of unfavorable climatic conditions which minimized the merchantable yield per acre. In 1915, an exceptional year, over 5,500 acres were harvested.

In approaching the region from all directions one sees distinctly the terminal moraines and other glacial deposits. (Fig. 1.) The deposits at the north are part of the watershed between the Ohio River system and the Lake Erie drainage basin. The drumlins and kames at the west and south enclose the marsh and divide the waters of the Scioto Valley from those of the Miami Valley. The gravel from these glacial deposits has been used in making the numerous roads within the marsh and as well in making the deep "fills" in the construction of the Erie Railroad across parts of the former bog.

---

[1]The writer acknowledges much helpful advice given by Dr. Eugene Van Cleef and other colleagues in the preparation of this study.

[2]Dachnowski, Alfred. Peat Deposits; Geological Survey of Ohio, Bulletin 16 (1912), p. 72.

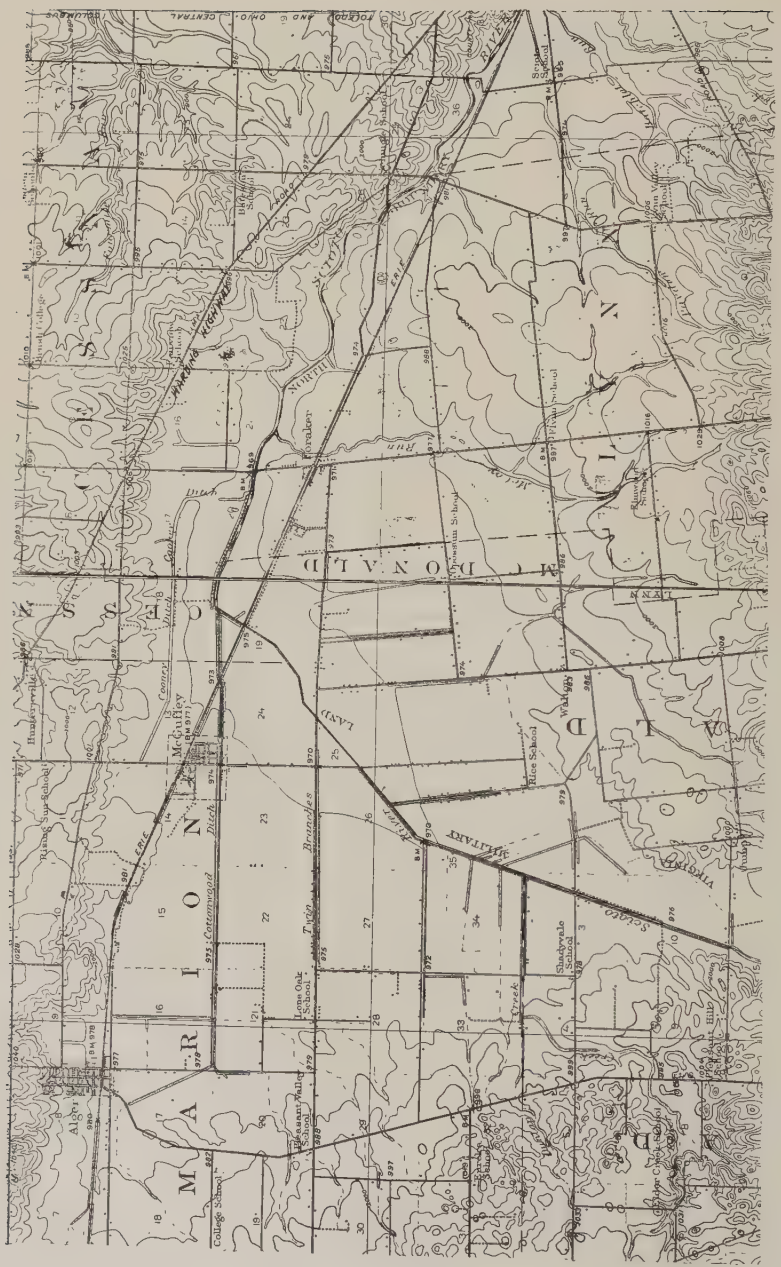


FIG. 1. Topographic map of Western Hardin County, including the area of the Scioto Marsh. (Scale: 1 inch = 1 mile. Contour interval 10 feet.)

LOCATION AND ACCESSIBILITY.

The area is crossed by the main line of the Erie Railroad and is less than ten miles away from the main line of the Pennsylvania Railroad, both roads connecting Chicago and New York City. It benefits by proximity to these lines of transport, for by a very short haul the agricultural crops can readily be exported to the great centers of food consumption. Paved roads through the middle of the marsh join the east-west Harding Highway, one of the main federal highways in North Central Ohio. Gravel roads built upon the banks of the dredged streams provide access to every farm and facilitate the speedy movement of the crops to the trunk highways and railways.

THE SOIL AND DRAINAGE.

The Scioto Marsh is the drained area of a former glacial lake.[3] For approximately 10,000 years the basin was in the process of being filled by the accumulation of vegetation.[4] It was deposited over layers of shell marl and clay which were washed into the former lake by the freshet streams which flowed into it. This action has produced a layer of peat material from two to ten feet in depth. The peat material, which coincides with the 980 foot contour line, provides a deep soil of amazing fertility. This region ranks among the best farming land in Ohio.

The floor of the basin is perfectly flat and unbroken in appearance save by the low dikes along the dredged watercourses. Rows of willow trees planted to serve as windbreaks cut the agricultural land into many plots, but these trees only accentuate the flatness of the great lacustrine plain. (Figs. 2, 3.)

Artificial drainage of the bog marsh was begun in 1859, but little was accomplished. It was resumed in 1883 and virtually completed in 1887. The Scioto River, which enters the Marsh at the southwest was, before drainage, said to be "lost" in the bog. One of the pioneers said that there was no river channel and that the present arbitrary course of the river

[3]Winchell, N. H. Geological Survey of Ohio; Vol. II, p. 353.

[4]Dachnowski. *op. cit.*, p. 73. "It is believed that the Indians by burning the grasses and sedges for the purpose of driving game from their hiding places delayed the filling of the basin."

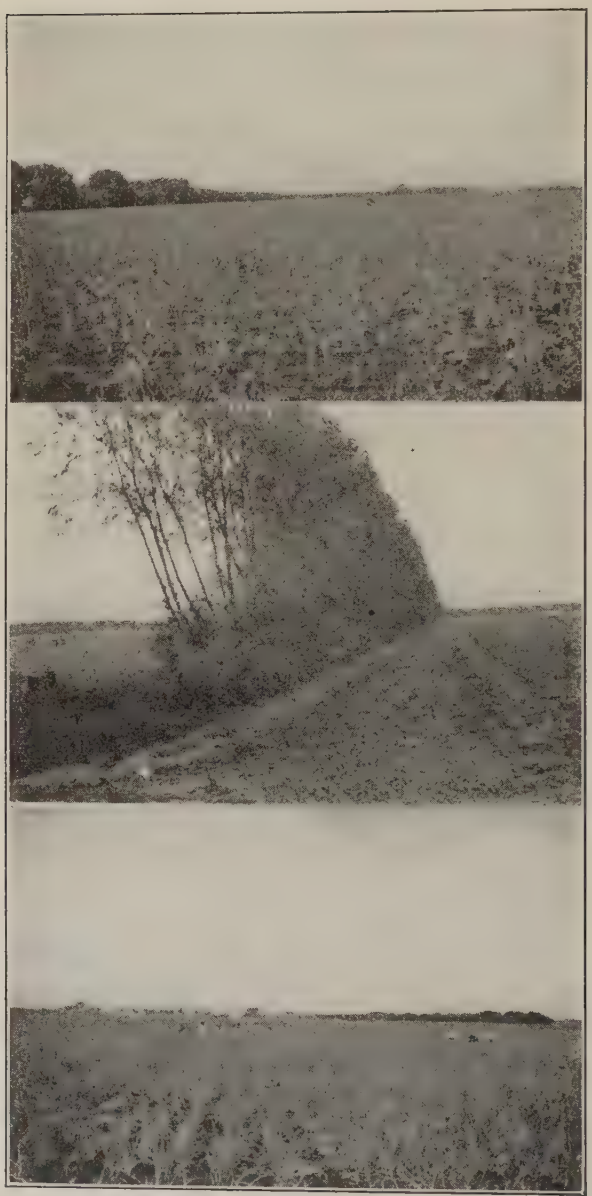


Fig. 2. The Scioto Marsh area includes 16,000 acres of distinctly level land.

Fig. 3. Willow trees are planted to break the force of the winds which in early spring cause severe losses by blowing away the loose "muck" and seeds before rooting has started.

Fig. 4. Each "weeder" cleans two rows as he crawls along protected against the hot sun by his wide-brimmed straw hat.

Fig. 5. A characteristic "workers" house provided for the migratory laborers from Kentucky. Most of these are located upon the dikes of drainage ditches.

Fig. 6. The method of filling the crates is fairly simple. Sheep-shears are used to cut the tops, which are discarded and left to fertilize the soil.

Fig. 7. Permanent storages (right) located near the double tracked Erie Railroad facilitate the speedy shipment of the crop to the chief centers of consumption.

is the result of the surveyor's lines. The present straight course of the river (Fig. 1) seems to lend support to this statement. Drainage lowered the natural outlet of the Marsh at the eastern apex of the lowland triangle. The main channel of the Scioto River was joined by many lateral ditches. In these ditches the sluggish speed of the water causes considerable silting. Almost constant dredging is necessary to keep them functioning properly.

Drainage has transformed the former bog into an agricultural province which is today completely cultivated. Excessive drainage has transformed the surface peat in several localities into a fine-grained material which is readily eroded by the wind. Dust storms in early spring are not an uncommon occurrence.

CLIMATE.

The distribution of temperature and rainfall during the growing season, May to September, is ideally suited to the onion crop. The period between the last killing frost, dating about May 5, and the first killing frost, averaging October 7, gives a growing season of about 154 days.[5] During this period the range of the average monthly temperatures lies between 60° F., for May, and 73° F., for July.

The rainfall during this season averages somewhat over half of the normal annual rainfall of 36 inches. (Chart 1.) September, the driest month of the growing season, is favorable for the harvesting and field storage of crops. The spring season usually is humid and windy. However, in some years an early drought occurs and then the wind is free to blow away the fine dried-out peat as mentioned before.[6]

Very high and very low temperatures are frequently recorded but these rarely affect the growing crop. From 1920 to 1930 the average of the annual maximum temperatures was 96.3° F. The minimum temperatures during the above decade averaged —7.6° F. The low winter temperatures are dangerous to stored onions unless the warehouses, called storages, are constructed extra well or have heating facilities.

---

[5]Peattie, Roderick. Geography of Ohio, Bulletin 27 of the Ohio Geological Survey, pp. 18-20. (After W. H. Alexander, Meteorologist, United States Department of Agriculture.)

[6]In some years the onion fields must be seeded three times due to wind erosion.

CULTIVATION IN RELATION TO CERTAIN WEATHER CONDITIONS.

Abnormally humid spring weather will check the growth of the onion roots so much that the plants tend to grow on top of the ground with the general result that the bulbs are of small size, although the tops have grown very high. When a thunderstorm is followed by hot sunshine the tops are "scalded" and growth then ceases.

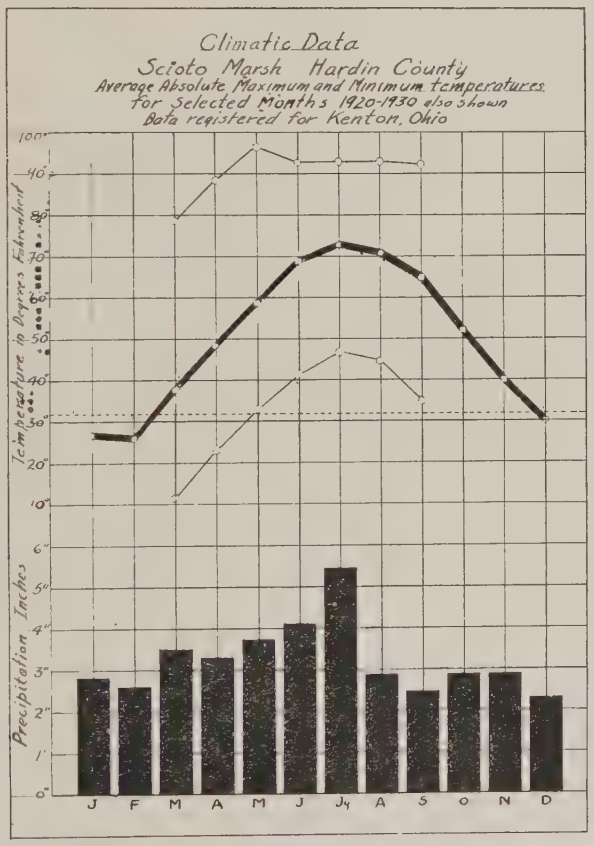


CHART 1.

A fairly dry spring seems to produce a great root length and a good plant. A series of fairly dry seasons has provided high merchantable yields while a series of wet seasons has resulted in the growth of small onions of relatively low market value.[7]

[7]Table I, yield for 1922. Excess rainfall 10.45 inches.

While a season of slight drought is favorable for onion crops, a particularly dry summer tends to bring about a fire hazard. Peat soil is combustible.[8] In 1914 a "muck fire" damaged nearly 100 acres of excellent soil and so threatened the whole area that it was necessary to call the state militia for fire-fighting purposes.[9]

THE PEOPLE.

Three village settlements—Alger, Foraker, and McGuffey—are located within the area. They act as "service stations" and cater to the simpler wants of the people in supplying groceries, everyday clothing, and other necessities. To some degree they are important as places of amusement. They are the shipping centers for the agricultural surpluses, each of them being served direct by the Erie Railroad.

A form of trans-humance is practiced by a great number of laborers who migrate between this locality and their original homes in the "Mountain Country," mostly from Breathitt, Perry and Letcher and adjacent counties in southeastern Kentucky. It is not definitely known why these people were attracted to this area, but it is reported that they were induced to come by some of the growers who saw the need of a great many seasonal laborers who could be depended upon to work conscientiously (for relatively low wages).[10] It is estimated that on an average somewhat over 400 families make the annual migration. They travel for the most part in their own automobiles.

The clannish customs and suspicious ways prevailing among these people are rather striking in contrast to life of the local land owners and permanently resident farmers. These laborers are sociable among themselves, but non-communicative to the casual traveler; however, after proper introductions are made they are ready conversationalists. They tend to retain and use curious words which are associated with the Elizabethan Age in England. The writer noted such common expressions

[8]An analysis of soil taken in the middle of the area by Dachnowski (Footnote 2) showed that dry peat contains volatile matter of 59%, fixed carbon 27%, sulphur 1.2%, nitrogen 3.4%. Dachnowski, *op. cit.*, p. 73.

[9]Information given to the writer by Judge W. W. Bowers, Secretary of The National Onion Grower's Association, Kenton, Ohio.

[10]Conversation with Mr. Val McGuffey, a pioneer resident of McGuffey, Ohio. He reported also that Negro labor was used formerly for a short time, but that it was unsuccessful presumably due to the social friction which occurred.

as "yit," for yet, "git" for get, "clum" for climbed, "fur" for for, "holp" for help. They refer to their luggage as a "budget." When one hears that the onion "crap" was "mightily plenteous" he is carried back to Elizabethan England.

These folk are honest, but not particularly thrifty. Some who elect to remain in the area during the winter in certain years are often dependent upon official charity even when their earnings have been considerable.

Meagerly furnished houses of one or two rooms (Fig. 5) are provided generally without cost to these migratory families. It seems that such houses are no better or worse than the cabins in which they live in the Kentucky Mountains.[11]

PRODUCTION MECHANICS.

The seeding of the onion lands begins normally about the first of May. Seeds are planted in rows about twelve to fourteen inches apart. Both domestic and foreign seeds are used; a few of the growers produce their own seed. Virtually no stirring of the soil is necessary in cultivation, but the problem of weed eradication is a large one. While on some farms the hand wheel hoe has been adopted as the means for keeping the crop clean, generally it is found that hand-weeding is the most practicable and profitable. Men, women, and children, on hands and knees, and wearing broad-brimmed straw hats (Fig. 4) crawl back and forth along the rows (each person taking two rows or more) pulling the weeds as they go. They drop them in place where they soon wither under the hot rays of the summer sun. Weeding must be done continuously owing to the fact that the weeds thrive as well in the rich soil as the onion itself. Although the weeds do not seed themselves, copious quantities of seeds are blown in from the surrounding lands to aggravate the problem annually. The great labor expense for weeding is believed by many of the growers to be a large cause for the small profits in the onion industry within this area.

Harvesting begins when the onion tops begin to wither. This is usually in mid or late August and very rarely does it begin later than September 1. Some growers stop the growth of the onion by lightly rolling the tops to break them, thus

[11]Davis, D. H. Journal of Geography, Vol. XXIX. (1930), pp. 90–91. (Photographs of Mountain Cabins in southeastern Kentucky.)

gaining a slight time advantage in early marketing. The onions are pulled by hand. On most of the farms it is the practice to throw several rows of onions together for a few days drying before the topping begins.

The "toppers" hold a large handful of onions over a crate (Fig. 6) and snip the tops with sheep shears. The crates when filled are stacked usually four crates high for further drying and covered with tar paper to await the buyer.

The grading and cleaning of the onions is done in a long inclined slatted rack into which they are dumped crate by crate. They are mulled over by hand to push the small onions through the slats and to loosen the excess onion skins which with the clinging soil falls or blows away. This is done in the fields and in field storages. Onions larger than one and three-eighths inches in diameter are classified as U. S. No. 1, known to the trade as "boilers;" those smaller are called "picklers." For shipping they are packed in bags of 100 pounds, stamped with the proper grades for the market.

MARKETING THE CROP.

Nearly all of the average crop of 1,000,000 bushels (Table I) is handled by brokers, called "buyers," many of whom are growers as well. In a poor season of low production, buying may begin even before harvest, but usually it begins as harvesting is finished. The brokers have wide contacts in the large consuming centers in all parts of the United States and Canada, while the tenant or "share-farmers" have none and of necessity pass to the buyers the job of placing the crop on the market. Competition is frequently keen among the buyers, especially for certain kinds and classes of onions. Personal honesty ranks high and virtually all of the sales contracts are made orally. The writer witnessed one sale of 20,000 bushels which was consummated by a single offer and acceptance which took less than a minute after an inspection of three crates of onions had been made.

Onions are perishable and little if any of the crop may be successfully or profitably stored after April 1, even in the best storages. (Fig. 7.) Few of the growers care to attempt long storage in common onion sheds on the farms for the winters with freezing weather bring disastrous results to a commodity with such a high water content.

The distribution of the crop is wide. Coal mining regions and steel making centers are especially good markets and have been found to provide a greater per capita consumption than other centers. Southern markets seem to demand Ohio onions, and a great many cars are sent to Louisville, Atlanta, Birmingham and Memphis. New York City buys 18 cars of onions per day. Chicago consumes nearly four cars per day.[12] The total average annual shipment to all markets is 1,800 cars.

TABLE I.

PRODUCTION OF ONIONS IN HARDIN COUNTY, OHIO, 1920–1930.
(Data from U. S. Department of Agriculture.)

YEAR	BUSHELS	ACREAGE HARVESTED	BUSHELS PER ACRE
1920	1,158,000	f	340 g
1921	617,000	f	225 g
1922	1,550,000 c	f	400 g
1923	780,000	f	253 g
1924	1,504,000	4,050	350
1925	255,000 a	1,200	298
1926	582,000	2,500	247
1927	1,500,000	4,400	330
1928	530,000	3,500	147 b
1929	930,000	4,300	260
1930	1,056,700 e	3,800 d	278
Average	951,150	3,583	284

a. Severe drought. Precipitation April–September, 9.87 inches. (Normal, 17.72 inches.)
b. Severe maggot infestation.
c. Copious rainfall. Precipitation April–August, 28.17. Normal, 17.72; excess, 10.45.
d. Decreased acreage probably due to low prices of 1929.
e. Preliminary estimates.
f. Data not available.
g. Data by Mr. H. C. R. Stewart, Crop Reporting Service, United States Department of Agriculture.

RELATION TO OTHER GROWING AREAS.

Ohio onions must compete with those grown in many other states, as well as with importations from abroad. Smaller onion producing areas are located in many parts of northern Indiana and Illinois, southern Wisconsin and Michigan, in many parts of western New York, here and there in New

[12]Conversation with Hon. J. B. Stambaugh, Ada, Ohio, former president of the National Onion Grower's Association.

England. There are scattered fields in southeastern Texas and still other widely separated fields. (Fig. 8.)

Twenty-five foreign nations ship onions in varying amounts to the United States. Spanish onions come in at the same time the Scioto crop is being harvested. England, Germany, Denmark, Canada, and even far-away Australia are general competitors.

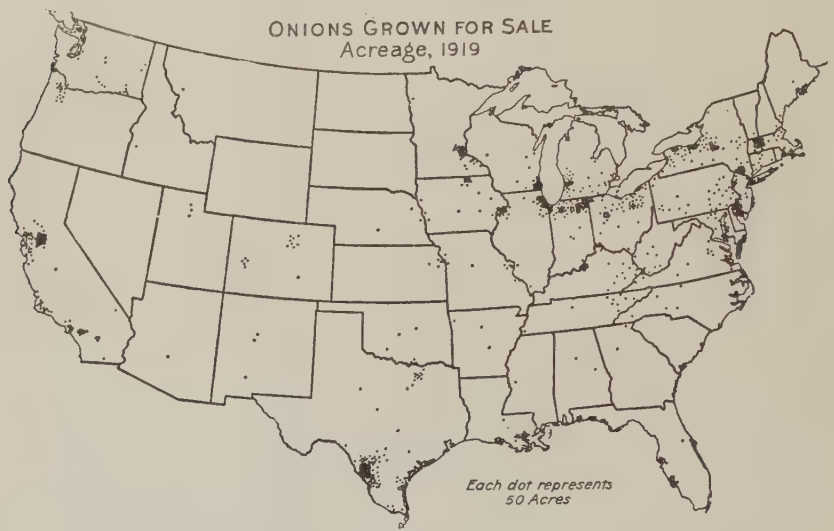


Fig. 8. Distribution of onions grown for sale in the United States. (U. S. D. A.)

The National Onion Grower's Association has succeeded in securing an increase in the tariff rate from 1 cent to 1½ cents per pound, an increase of 50%, which became effective on January 1, 1929. This was raised by the Smoot-Hawley Bill of 1930 to 2½ cents per pound. This is expected to give some advantage to domestic producers everywhere. The industry is one of large proportions and according to many of the Scioto Marsh growers has been an industry of very small profits for the past four years. However, should foreign importations be sharply reduced under the new tariff act of 1930, as is confidently expected, the acreage on the Scioto Marsh should undoubtedly rise to former high levels.

THE NATIVE IRIS OF OHIO AND BORDERING TERRITORY.*

A. E. WALLER.

Sufficient progress in the study of the native American species of the genus Iris as locally represented has been made during the past five years to warrant the publication at this time of a list with a key and distribution maps. Before 1926 the State Herbarium had only two species listed, the northern blue flag, *Iris versicolor*, L. and the crested dwarf Iris, *Iris cristata* Ait. The leafy blue flag, *Iris foliosa*, Mack and Bush, although known to have been collected in the state, was not represented in the Herbarium. The intervening years since 1926 have witnessed an awakening enthusiasm for native iris, occasioned in part by collectors of garden iris, but chiefly resulting from the availability of certain valuable botanical publications. These Iris papers have shown conclusively that in spite of its showiness and the natural attractiveness of its flowers, the genus has been decidedly neglected by the botanists. A conspectus of the genus, which has about 170 species, goes back to Sir Michael Foster and Mr. W. R. Dykes. The former's great interest in collecting and classifying, after having grown the plants, bore fruit in the monograph of the genus by Dykes (2) published in 1913. The monograph, probably not circulated much beyond the greater libraries was happily followed by a Handbook (3) in 1924 by the same author. The Handbook furnishes a convenient guide to anyone interested in the genus and has made it possible for the many garden enthusiasts to become acquainted with a group of most interesting plants. During the same period, Dr. John K. Small (6), (7), of the New York Botanical Garden, has added a new interest to native American iris by his collections of many fine forms in the Southeastern States from Florida to the Mississippi Valley. Also during this period, Mr. Edgar Anderson (1) of the Missouri Botanical Garden, has cleared up the confusion in nomenclature of *Iris versicolor* and has shown that what was negligently classified under that name is really a pair of distinct species with definite characters and decidedly different geographic ranges.

*Papers from the Department of Botany, The Ohio State University, No. 268.

The purpose of this paper is to call attention to our local species. Since the political boundaries of the State bear no relation to origin or migrational history of a group of plants, it is thought best to include such native American species as we have in our closely surrounding neighboring States, attention being in each case given to the proved records of their collection from actual Ohio territory.

METHODS OF STUDY.

The collection of iris into gardens lends itself particularly well to modern taxonomic study which at present demands more than the preservation of good herbarium material. There are several reasons for herbarium specimens being unsatisfactory. The first one is that iris flowers are perishable and delicate and not easy to determine in the dried state. Iris specimens usually defy all attempts at dissection. Few herbaria have specimens with complete parts of the plants included. Seeds, capsules, rhizomes are all wanted for the diagnosis of certain species. The student of iris will do well to bear in mind that the collection of entire plants and the notes on habitats and time of bloom are important. Too much stress has been laid upon flower color, quite the most easily lost of all the characters. After a few years the Albino forms recorded in several species are completely indistinguishable from the dark forms in herbarium sheets. Consequently all collections I have made are supplemented with garden culture of doubtful species. With this method of study it has not taken long to show that the descriptions of species in our general manuals of botany are in need of revision. Few of the manuals present in concise form those differences needed for diagnosis. None have taken advantage of the convenient grouping of the species into subsections of the genus. The examination of the following paragraphs will show that the determination of a few endemic species is made easier by a study of the relation of the species to the genus as a whole.

SECTIONS, AND SMALLER GROUPS OF THE GENUS.

The iris forms commonly grown in our gardens are characterized by a prominent beard on the sepal. This has no functional significance, although inexperienced hybridizers have been known to mistake it for the stigmatic surface of the plant. It is intended at a future date to take up the naturalized species

as it can be shown that a number of garden forms have escaped in Ohio and a number of species have become naturalized. The point in this connection is that we have no native bearded iris or Pogoniris in Ohio. The two main groups into which our native species fall are the *Evansia* section and the *Apogon* section of the genus.

The *Evansia* section derives its name from Thomas Evans, of India House, who first introduced a crested iris to the botanists in Great Britain. It was at one time given a separate generic name, *Evansia*, but was later put back into the genus Iris after several somewhat similar forms became known. All the Iris of this section have the median line of the sepal decorated with a white or yellow linear crest usually of three small ridges, more or less bearded or waved. The crest in the iris of this group, replaces the beard of the previously mentioned group of garden forms. Our native American species, *cristata* and *lacustris*, are the members of this section. Most of the species of the crested group are from India and China and probably most of the 8 or 9 described species have garden possibilities. Tectorum is the Chinese species most commonly introduced into our gardens.

The *Apogon* section is large and comprises nearly half the genus. However, it is so conveniently split up into a number of smaller subsections that are readily grasped by the iris growers that the whole section is scarcely ever thought of as having unity except in two main points. The iris are all without beards or crests and they are all rhizomatous. Taken together these two characters separate the Apogons from the bearded iris and the crested iris as well as the bulbous iris. If any ornamentation of the median line of the sepal exists, it takes the form of a color stripe or a minute pubescence. It is not until the fundamental divisions of the iris groups are borne in mind that a manual of local forms can be properly constructed, and be useful to some one not already acquainted with many irises.

In our American species the Apogon section is represented in Ohio by the Hexagona subsection and by a subsection that will be proposed a little further on in this paper. The Hexagona subsection derives its name from the six-angled or six-sided seed capsule. The ovulary of the Hexagona group of iris is subtended by three narrow linear troughs extending from base to apex. These troughs are bounded by prominent ridges forming ribs. The wider and more or less flat faces may also

have minor ridges on them. This subsection is distinctly American and contains three species, *I. hexagona*, native in the Carolinas, not known outside of cultivation in Ohio; *I. fulva*, with a distribution center in the Mississippi Valley, but known in Ohio, and *I. foliosa*, known since 1926 to be rather widely distributed in Ohio. From the time of the proposal of the name in 1902 until 1926 the occurrence of this iris had only been definitely recorded for the State Herbarium from a colony on Middle Bass Island. There were specimens from Ohio, however, in other herbaria.

Two species of Apogons obviously closely related to one another are *Iris versicolor* L. and *Iris virginica* L. They are enough like each other that the hasty superficial methods of collecting only flowers and then finding in the herbarium a mass of collapsed material that is more an exasperation than a record, has led for many years to indiscriminate lumping of all of these under one name, versicolor. This species was thought to have been the only one of the blue flags native in Ohio. This mistake was unfortunately not realized by Dykes. Probably because of lack of critical material easily at hand, these two species were not separated in Dykes Monograph. Possibly he may have looked askance at the problems of untangling the synonymy and deferred to the current American diagnosis. It is easy on this ground to account for his remarkable summary of the range of versicolor, from Hudson Bay to the Gulf of Mexico, a range which on the Age and Area Hypothesis would readily concede to versicolor the parentage of all other iris species.

NEW SUBSECTION OF APOGONS. THE VIRGINICA SUBSECTION.

The separation of the two species has been carefully explained by Mr. Anderson, (loc. cit.) with full references to all the records of taxonomic importance.

Since Dykes did not separate the two and Anderson in making the separation used his material in such a way that the affinities are not emphasized it is here proposed to group these two into a new subsection of the genus and call it the Virginica subsection. Dykes was interested in attempting to show similarities between versicolor and Iris pseudacorus, the yellow European bog iris. Attention to this led him away from the more logical and more important consideration of the virginica-versicolor problem.

The Virginica subsection of the Apogons may be defined as comprising versicolor and virginica. It is distinct from the Hexagona group and the western group, but is related to the Gulf Coast forms.

The remaining single species of the area covered by this paper is *Iris verna* L. It does not belong to any other group of species of the Apogons. It has in the past been variously grouped, but does not have close affinities with any members of the genus. It is dwarf and has been confused with cristata, but it lacks the crest found in all Evansia irises. It is beardless, but bears on the median line of the sepals a marked pubescence of short unicellular hairs. The small flowers with erect standards and spreading falls give it somewhat the appearance of a diminutive bearded iris. However, it is not related to the dwarf bearded irises. It has not definitely been proved to be in Ohio, but is suspected and is known not far south of the Ohio River in Kentucky and West Virginia, and probably also west of Ohio, in Indiana.

Further remarks on the above plants will be postponed to examine a key to the species before discussing these individually.

Key to Native Iris.

A. Dwarf plants without flower stalks, flowers borne on relatively long perianth, tubes, sepals crested.
  B. Perianth tube narrowly funnel form, 1½ cm. to 3 cm. long, shorter than the sepals.....**I. lacustris.**
  B. Perianth tube broadly funnel form, 4–7 cm. long, as long or longer than the sepals.....**I. cristata.**

A. Dwarf plants with short flower stalks not exceeding the perianth tube, the two together less than 7 cm. long, sepals not crested, petals somewhat arching cupped.....**I. verna.**

A. Plants with flower stalks at least 8 cm. long.
  B. Hexagonal ovularies.
    C. Flower stalk erect, 20–50 cm. long floral segments drooping, sepals and petals coppery red.....**I. fulva.**
    C. Flower stalk curved, often zigzag, sometimes procumbent, usually less than 40 cm. long, sepals and petals spreading horizontal, blue to lilac.....**I. foliosa.**
  B. Trigonal ovularies.
    C. Flower stalk sparingly branched, ovules filling the locules, sepals usually with bright yellow blotch at base of blade, blade pubescent sepals thin textured, easily wilting, blue purple or lighter, capsule lining dull, seeds dull, corky, both rounded and D-shaped.....**I. virginica.**
    C. Flower stalk freely branching above, ovules not filling the locules, blotch, if present, green or greenish yellow, sepals relatively heavy textured, not easily wilting, reddish purple, capsule lining shiny, seed coats relatively thin, shiny, D-shaped.....**I.versicolor.**

DISCUSSION OF THE SPECIES AND THEIR DISTRIBUTION.

Iris cristata Ait. Hort. Kew. 1: 70. 1789.

Plates. Dykes, pl. 25. Addisonia, pl. 320.

Description—The stem is a slender rhizome which spreads by long stolons. In a favorable location the stolons may be 6 or more in number and rather short. In the native state on eroding stream banks the stolons may be 15 cm. long without lateral buds forming. The leaves are usually less than 12 cm. at flowering time, but may be twice that length later in the season. In width they are between 1 and 3 cm. The flower stalk is short or absent and bears two or three reduced leaves at the base. The perianth tube is greatly elongated up to 10 cm., 3 angled and distinctly wider at the top. The falls (sepals) do not have any constriction separating blade and haft. The blade is broadly obovate and surmounted by three ridges. The central ridge is waved, white, tipped with orange. The lateral ridges are orange or yellowish. The central ridge becomes dotted with purple toward its apex around which is a white patch sharply outlined with lilac purple which fades to paler lilac toward the margins of the blade. The standards, (petals) are horizontal or drooping. The style branches are appressed over the falls. The stigma is oblong entire, the filaments are white or tinged, the anthers cream and the pollen white. The capsule is small, not more than 1½ cm. long. It dehisces while still green and somewhat hidden by the spathe valves. It is sharply trigonal, broader at the apex and tipped with a small point. The seeds are small, oval, and bear small gelatinous appendages which are viscid at first, but shrivel quickly on being exposed to the air.

This interesting little plant was introduced into England by Peter Collinson in 1756. It was well known to John Bartram, to Short, and other botanists of pioneering days.

Through the courtesy of the Missouri Botanical Garden I have studied their collection and find that its range exceeds that given by Small, Dykes and others.

Distribution—Iris cristata ranges through the hilly sections of Georgia and the Carolinas, across Virginia, Tennessee and Kentucky, north across Ohio to Lake Erie, across to Southern Indiana to Missouri, Arkansas and Texas. It is decidedly a plant of the Appalachian Highland rim spreading out to the Ozarks and south westward. In Ohio in post-glacial times it has migrated across the hilly eastern part of the state.

Habitat—Drained but moist and cool soils are occupied by Iris cristata. It may form a mat in association with ferns, mosses, violets and other plants of moist rock faces, but it is equally a part of drained terraces and flood plains in partial

shade. As a garden plant it can be better managed in soils that have well decayed humus incorporated and kept cooled by the shade of small trees or shrubs. The stolons do not spread so far and strong clumps bearing numerous flowers are formed. Rhizomes that have flowered do not again flower. They may be discarded to make room for young stolons. Iris clumps help solve the erosion problems of partially shaded garden terraces and make ideal plants for the base of a wall wherever height is not wanted. It appears that seeds are not easy to germinate and in plants collected from vigorous patches seed production is never very heavy. The question raised by Dykes whether or not the albino form appears in the wild state or only in gardens can now be answered. Mr. Floyd Bartley, of Circleville, Ohio, brought me some white forms collected in Hocking County, in East Pike Run, where it occasionally appears among the blue flowered plants. A specimen is in the State Herbarium from this locality.

Iris lacustris Nuttall. Gen. 1:23. 1818.

Plate. Addisonia, Pl. 319.

Dykes Genus Iris, p. 106, makes *I. lacustris* a variety of *I. cristata*, but in the Handbook, p. 85, he appears to have reversed his earlier opinion and gives it as a species. The description on p. 86 is not convincing. The key in this paper gives the major points by which *I. lacustris* may be distinguished from *I. cristata*, namely, the dimensions and form of the perianth tube. In other characters there are also differences, though it must be admitted that the species are closely linked. The type specimen collected by Krebs is in the Herbarium of the Berlin Botanic Garden and has not been examined, though the Ohio State University has the material on *I. cristata*, collected by Krebs. Both are labelled "collected in Cuyahoga County." The best material I have seen of *I. lacustris* was collected and kindly sent by Dr. George E. Nichols, from Douglass Lake, in Michigan. Michigan and Ohio are the critical states for the determination of these two species as it is there that the distribution shows an overlap. In garden cultivation with me, *I. lacustris* has never succeeded well, though growing side by side with *I. cristata*. While this is not sufficient evidence, it leads me to suspect that the separation had occurred before glaciation and that *I. lacustris* was preserved

in its more northern habitat on some of the unglaciated areas, while *I. cristata* was forced into a temporary retreat in the region southeast of the Moraines of Fairfield County. At least *I. lacustris*, as the name implies, has its center of distribution in the Great Lakes region.

Iris verna Linnaeus. Sp. Pl. ed. 1, p. 39. 1753.

As mentioned previously, this dwarf iris is not at present officially recorded from Ohio. It has been reported from Adams County. However, it is thought desirable to spread our area a little to include it since it is becoming a familiar form in cultivation and it is not necessary to go far south of the Ohio River to find it in the wild state. A few years ago it was seen in a flourishing condition in the pine woods at the top of the hill at Natural Bridge, Kentucky.

Description—The stem is a slender rhizome, not bearing long stolons as in *I. cristata*. The leaves are narrowly ensiform, 10–16 cm. long at flowering time, later somewhat longer. The flowering stalk is short, the perianth tube 3–4 cm. long, rounded to trigonal. The ovulary is trigonal, the mature seed capsule with a groove on each face, is blunt at the base and tapering to the apex. The sepals are about 3 cm. long and less than 1 cm. wide, obovate cuneate. The haft is marked by a pubescent band of unicellular hairs, orange and brown, extending outward to the blade, which is uniformly purplish lilac. The falls are horizontal and the standards are arching cupped and of the same color as the blade of the falls.

The style arms do not separate at the base of the segments, but about ½ cm. higher. The styles are lighter than the blade of the falls in color. The stigma is entire. Filaments are white or tinged, longer than the anthers. The anthers are blue, the pollen creamy white. The seeds are pear-shaped, a light brown and marked with a raphe of white.

Distribution—The range of *I. verna* is in the Southern Appalachians, but it nowhere forms the matted colonies which make a conspicuous plant of *I. cristata*. It has been collected from Virginia, Kentucky, Tennessee, North Carolina, Georgia, and Alabama.

Habitat—*I. verna* requires greater drainage than *I. cristata*, but still requires somewhat cool soil in the summer. It can be successfully lifted and transplanted in early autumn in Ohio and a planting made of it five years ago to a well drained shaded slope not far from a limestone gravel walk has thrived without further attention. A planting made at the same time and put

into soil that was acidulated with alum died promptly after flowering the first year. This seems to be the reverse of the experience of most gardeners. The leaves are decidedly slower to die and absciss than *I. cristata*, a fact that commends it to the attention of gardeners looking for dwarf plants with more or less evergreen foliage.

Iris fulva Ker-Gawler. 1812.

Plate in Botanical Mag., 1496. Pl. in Dykes, Genus Iris, 21. Seeds, Pl. 48, Fig. 3.

No iris is more readily identified than *I. fulva*, in which the flowers are apparently lacking in the violet or purplish tones so abundant in most iris species. The color is according to Ridgeway's charts (4) between cornelian red and vinaceous rufous. (Plate 14). This is far from the conventional description as terra cotta, given both in the Genus Iris and in Dyke's Handbook and consequently found in a number of other writings. The color is far too brilliant to continue to mask under such a drab designation. The flower color and the hexagonal ovulary are sufficient to distinguish it.

Description—The rhizome is stout, becoming green if exposed and bearing the shredded leaf bases on prominent scars of the successive years growths. The flower stalk is 60 cm. or more long and bears two flowers at the apex and one or two more in the axils of short leaves. The ovulary is six-ribbed and at maturity the seed capsule may be 5 cm. long by 2 cm. broad. The sepals are oblanceolate cuneate, nearly 3 cm. broad at the widest part of the blade. The petals are emarginate and truncated. Sepals and petals are of a uniform color close to cornelian red or dark at the veins. The styles are short, about 2 cm., the stigma bears two small pointed teeth. The filaments are yellow, the anthers cream, reaching the stigma, the pollen is cream. The seeds are large, flat sided and covered with a thick coriaceous husk.

Distribution—The range of *I. fulva* is given in the Genus Iris and in the Handbook of Dykes as limited to the banks of the Mississippi near New Orleans. It is known to range from there as far north as Illinois and is reported eastward as far as Georgia. It is also known from the moister parts of Texas and Arkansas and its distribution in Western Tennessee and Kentucky is suspected.

Habitat—I. fulva is distinctly a swamp plant, tolerating poorly the dry conditions of most gardens. It is best planted close to a stream where it can be kept moist. The plants that I have known for the past fifteen years have been in a pasture

on the farm of Mrs. Joseph Wing, near Mechanicsburg, Champaign County, Ohio, where they have spread without protection and have at times even been trampled, though never eaten by the livestock. While there is not an altogether clear record, the plants are supposed to have been brought from Clark County. I have never been able to disprove or to verify this statement, since the plants have been living in their present location without attention for such a long time. It is the habit of *I. fulva* to send out new shoots in autumn which seem perfectly able to withstand cold during the winter. The specimens in Champaign County have a number of times endured zero and lower temperatures. *I. fulva* seems fully as hardy as the related species, *I. foliosa*. It is recommended for trial in all gardens able to give it sufficient moisture.

Iris foliosa Mackenzie and Bush in Trans. Acad. Sci. St. Louis, 12:81, 1902.

Plate, Dykes Genus Iris, 20. Addisonia, 315.

Description—The rhizome is light brown, often with green from the leaf bases encircling it. The leaves are glaucous, 2½ cm. wide and 40–50 cm. long. In autumn when the leaves die away new shoots appear at once. These remain green, but do not grow until spring. The flower stalk is short, 15–25 cm., flexuous or distinctly zigzag so that its length is uncertain. The leaves at flowering exceed the length of the stem. The spath valves are green, 5 cm. long. The ovulary is six-angled and ribbed with six prominent ridges. The perianth tube is 1½ cm. long and ribbed. The falls are ascending spreading, a clear blue violet, the blade ovate, the haft narrowly cuneate. A large downy patch of white at the center of the falls extends in toward the haft, becoming greener toward the haft. The standards are oblanceolate of the same color as the falls. The styles are keeled, greenish along the keel. The stigma has two large lobes, the filaments are stout, about equalling the anthers. The anthers are wide, the sac being widely separated, the pollen is yellowish white and pointed. The capsule is about as wide as long, 3 cm. The ribs on the capsule meet in a rosette at the apex. The seeds are large, corky grayish buff and of irregular shapes.

Distribution—Since this iris is one for which a great number of records have been made recently, it seems desirable to give a few of these to show that this plant is not a rare one, but had merely escaped the notice of collectors. The earliest specimens were recorded as *I. hexagona* in 1897. The species *foliosa* was erected in 1902.

Iris foliosa Mack. and B.

Auglaize County—St. Mary's, A. Wetzstein, 1897, (*I. hexagona*).
Auglaize County—St. Mary's, A. Wetzstein, 1898, (*I. hexagona*).
Ottawa County—Catawba Island, Edgar Anderson, 1925.
Mercer County—Near Celina, A. E. Waller, 1926.
Shelby County—Near Sidney, Joseph A. Clem, 1926.
Franklin County—West of Glenmary Park, A. E. Waller, 1927.
Highland County—Hillsboro, Garden escape. Katie M. Roads, 1928.
Van Wert County—Willshire, A. E. Waller, 1929.
Darke County—Ten miles north of Greenville, Hicks and McCormick, 1930.
Henry County—One and one-half miles east of Napoleon, Hicks and McCormick, 1930.
Union County—One mile south of Essex, Hicks and McCormick, 1930.
Ottawa County—Middle Bass Island, C. J. Kennedy and Helen Brown, 1930.

The distribution by counties indicates clearly that this iris fits in with the distribution of Mississippi Valley plants that have migrated post-glacially northeastward along the Ohio, Wabash, and Maumee River systems across the northwestern part of Ohio. The farthest south distribution point in Ohio, Highland County, is recorded by Miss Roads as a garden escape. The farthest east record to date is Franklin County. It is further interesting to be able to record that I have seen colonies of this species in Wells County, Indiana, near the Wabash River, while collecting with Mr. E. B. Williamson, of Bluffton, Indiana. Both Mr. Williamson and Mr. Paul Cook, of Bluffton, have traced this species over to Willshire, Ohio.

Habitat—Iris foliosa is a plant of small stream terraces and succeeds well in partly shaded positions. The colonies spread vigorously and the corky seeds float to other parts of the stream. It is not easy to see how the great upstream migration could be accomplished in any but rather level country. The accompanying distribution map gives a reliable picture of the known facts. Both Sir Michael Foster and Mr. E. B. Williamson have produced hybrids of *I. foliosa* and *I. fulva* using the pollen of *I. foliosa*. These hybrids are rather widely grown in gardens, being more frequently seen than the parent species. The hybrid forms have the vigor and flower size of the pollen parent and the height of the seed parent. No second generation segregates have yet appeared in cultivation. The plants produced by the two hybridizers are readily distinguished by iris fanciers.

Iris virginica Linneaus. Sp. Plant. Ed. 1, p. 38 (1753).

Plate 36, Fig. 2, in Anderson (loc. cit.).

Description—Rhizome 2–4 cm. wide. Leaves 1–5 cm. wide, 60–80 cm. long, ensiform. Flowering stalk not much branched. Spathe valves long, 4–12 cm., sometimes becoming reduced leaves. Ovulary long, slender, 1.8–3.8 cm., walls of ovulary relatively thick, and the ovules nearly filling the locules. Sepals a blue purple with a bright yellow pubescent spot at the base of the blade. The thickness of the blade is less than the length of the hairs of the pubescences. Petals ovate spatulate, nearly as long as the sepals, of the same general color as the sepals, thin and easily wilted. The seed capsule is long and slender, the lining irregularly marked with striae, dull. The seeds are large, rounded to D-shaped, having a heavy cork wall and the seed coats are dull.

Distribution—Iris virginica appears all over our area. It is the common flag of our region and the earlier collections in the State Herbarium have been checked to separate *I. virginica* from the collection which was originally entirely labelled *I. versicolor*. We have herbarium sheets and sight records from most of the state. In the northwestern part of the State, *I. foliosa*, *I. virginica* and *I. versicolor* all meet.

Anderson, (loc. cit.) reports a partially sterile hybrid between *I. virginica* and *I. versicolor*. He obtained it as the result of an artificial pollination and also reports its spontaneous appearance in the areas of overlap of the two species. The Southeastern part of Ohio affords less opportunity for the occurrence of the swamp irises than the northern and western parts.

Habitat—Iris virginica is a plant of stream borders and marshy ground. It does not endure shade as well as *I. foliosa*, but in the open makes the most vigorous colonies of any of our iris species. It is increasing in moist pastures over the state as the livestock will not eat it except in the absence of all other herbage. It makes an excellent plant for water gardens, where a fine effect of vigorous foliage is wanted, and should have *I. pseudacorus*, the yellow swamp iris of Europe, as its garden associate. It is in my estimation a finer plant for garden effects than *I. versicolor*. Since its identity has not been clear it is uncertain whether all the garden forms that have been separated are from *versicolor* or *virginica*.

Iris versicolor L. Sp. plant ed., 1, p. 39. 1753.

Plates. Curtis, Bot. Mag. 1: Pl. 21, 1790. Meehan, Native Flowers and Ferns 1: Pl. 36, 1878. Small in Addisonia 9: 55, Pl. 316, 1924.

Description—Rhizome 1–2.5 cm. wide. Flower stalk freely branching above. Spathe valves 3–4.5 cm., never becoming leafy (see preceding species). Ovulary 0.8–2.0 cm. long in flower. Walls of the ovulary thin, ovules not filling the locules. Sepals a reddish violet, blade often without a conspicuous spot at the base. If the spot is present, the color is a greenish yellow to green. The pubescence of the base of the blade is short and inconspicuous. The petals are lanceolate, shorter than the sepals, and of firm texture, not readily wilting. The capsule is not usually as long as in *I. virginica*. The capsule lining is shiny. The seeds are D-shaped, shiny and regularly pitted and relatively thin.

Distribution—Part of the specimens heretofore erroneously labeled *I. versicolor* have to be reclassified as *I. virginica*. Instead of being widely distributed, this iris is found only in some of the northern counties of the state. To date the list of counties in which we unmistakably have *I. versicolor* consists of Williams, Fulton and Defiance in the Northwest, and Ashtabula, Lake, Cuyahoga, Geauga, Summit, Portage and Trumbull in the northeast, and Sandusky county in the center near the Lake. Perhaps further study will add the intervening counties along the Lake Shore, but we do not have records.

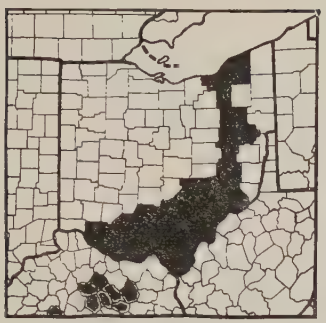
Habitats—Dispersal is by means of the floating seeds and many small streams emptying into the lake are populated with colonies of *I. versicolor*. The species spread is probably from the Great Lakes region across New York along the Mohawk and Hudson Valleys to Eastern Pennsylvania and Maryland. It is the only native species listed in the Flora of the Cayuga Basin, by Weigand and Eames (10). As a garden plant the reddish purple variety known as kermesina is without doubt selected from *I. versicolor* and is seen more frequently than any other form. Miss Sawyer (5) has reported on the cause of failure in attempting to cross *I. versicolor* and *I. pseudacorus*. She has shown in her scholarly paper that while some fusions within the embryo sac occur, the embryos fail to develop.

SUMMARY.

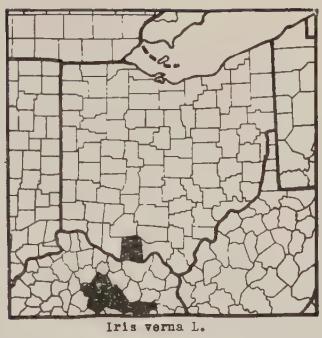
This account of seven species of irises growing in or near Ohio without cultivation shows the neglect of a striking group of plants in which there is an expanding public interest. That situation is also found true in the southeastern states where in addition to some of the irises named here there are a great number of other forms. A summarizing paper by Dr. Small, the Chronicle of Eastern American Iris (7) indicates the energy and enthusiasm he has devoted to the task of describing these new southern species.

REFERENCES.

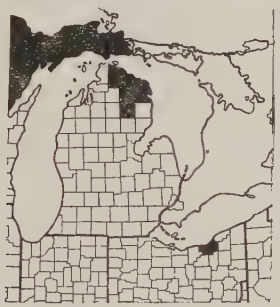
1. **Anderson, Edgar.** The problem of species in the northern blue flags Iris versicolor L. and Iris virginica L. In Annals Mo. Bot. Garden, 15. 1928.
2. **Dykes, W. R.** The Genus Iris. Cambridge University Press. 1913.
3. Idem. Handbook of Garden Irises. Martin Hopkinson, London. 1924.
4. **Ridgeway, Robert.** Color standards and color nomenclature. Washington. 1912.
5. **Sawyer, M. L.** Crossing Iris pseudacorus and I. versicolor. Bot. Gaz. 79: 60. 1925.
6. **Small, John K.** In Addisonia 9: 1924.
7. Idem. In Addisonia 12: 1927.
8. Idem. In Addisonia 14: 1929.
9. Idem. Chronicle of Eastern American Iris. Jour. New York Bot. Garden 31: 40–45. 1930.
10. **Weigand, Karl M.** and **Eames, Arthur J.** Flora of the Cayuga Lake Basin, New York. Cornell University, Agricultural Experiment Station, Memoir 92, p. 150. Ithaca, New York. 1926.



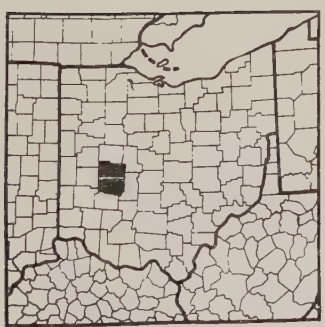
Iris cristata Ait.



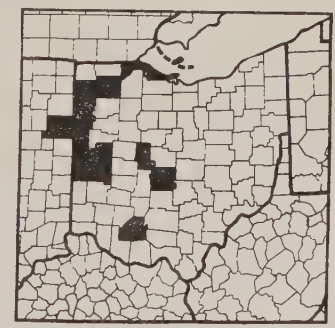
Iris verna L.



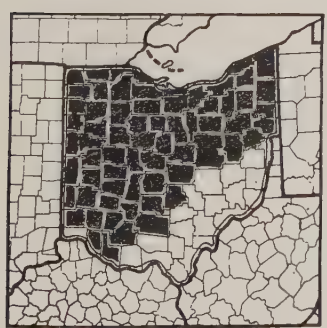
Iris lacustris Nuttall



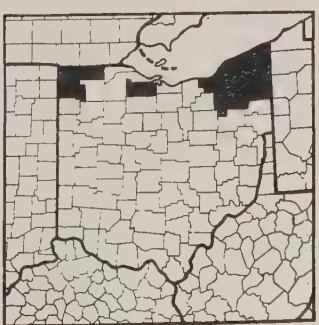
Iris fulva Ker.



Iris foliosa McK and B



Iris virginica L.



Iris versicolor L.

OHIO MOSSES, HYPNALES.*

NELLIE F. HENDERSON.

The present paper is the fourth on the subject of the mosses of Ohio and completes the preliminary study of the plants of that group in the state. The Hypnales have been treated in the same way as the other orders were treated in former studies. With a few exceptions, the classification and nomenclature are those used by Dr. Jennings in his Mosses of Western Pennsylvania. Thamnium is included with Climacium in the Climaciaceæ, following Dr. Nichols who includes them in one family which he calls Dendroidaceæ. In parenthesis, following the name cited, are to be found the names used by authors of the usual manuals on moss.

HYPNALES.

Mosses which usually have the creeping habit, frequently with pinnate or sub-pinnate branching; archegonia situated at the tip of short special branches or buds, not at the apex; the so-called pleuricarpous mosses. Peristome usually double with the inner set of teeth alternating with the outer ones.

This order is extremely variable both in vegetative characteristics and habitats.

SYNOPSIS OF THE ORDER HYPNALES.

I. Peristome apparently simple or wanting; the inner, when present, usually incomplete.
   A. Peristome double but with an incomplete inner peristome.
      1. Inner peristome of 16 filamentous teeth, imperfectly separated; no basal membrane.....FONTINALIACEÆ (1)
      2. Inner peristome of narrow segments; basal membrane low; on trees.....NECKERACEÆ (2)
   B. Peristome wanting.....HEDWIGIACEÆ (3)

II. Peristome double, inner well-developed, cilia wanting; calyptra mitrate.....HOOKERIACEÆ (4)

*Papers from the Department of Botany, The Ohio State University, No. 270.

III. Peristome double, inner usually with cilia, segments keeled and often split along the median line; calyptra cucullate.
A. Sporangium usually erect and actinomorphic.
1. Sporangium non-plicate; basal membrane present; cilia rudimentary, rare, or wanting.
a. Teeth non-lamillate; inner peristome rudimentary or none, LEUCODONTACEÆ (5)
b. Teeth with lamellæ on the inner surface.
1. Scales usually smooth.
a. Prostrate to ascending; sporophytes single, ENTODONTACEÆ (6)
b. Dendroid; sporophytes clustered....CLIMACIACEÆ (7)
2. Scales papillose.....LESKEACEÆ (8)
2. Sporangium plicate, no basal membrane, inner peristome none or of subrelate segments.....FABRONIACEÆ (9)
B. Sporangium inclined to pendent, usually zygomorphic.
1. Calyptra long-rostrate, oblique.....SEMATOPHYLLACEÆ (10)
2. Calyptra conic, obtuse or short-rostrate.
a. Alar cells quadrate, not inflated; green or hyaline, BRACHYTHECIACEÆ (11)
b. Alar cells rounded or 4–6 sided, mostly hyaline and frequently inflated.....HYPNACEÆ (12)

KEY TO THE FAMILIES OF HYPNALES.

1. Aquatic, ours long and floating with straight scales...FONTINALACEÆ (1)
1. Terrestrial, or if in water, with secund scales..... 2
2. Scales papillose.....LESKEACEÆ (8)
2. Scales smooth or only slightly papillose at the cell angles..... 3
3. Blackish; peristome wanting; on rocks; acrocarpous.....HEDWIGIACEÆ (3)
3. Light to dark green; peristome present; pleuricarpous..... 4
4. Segments of the inner peristome rudimentary..... 5
4. Segments of the inner peristome keeled or often split..... 7
5. Complanate, scales undulate.....NECKERACEÆ (2)
5. Terete, scales not undulate..... 6
6. Cells of the scales elongated; small soft mosses.....FABRONIACEÆ (9)
6. Cells of the scales short; coarse lax tufts; often pendent..LEUCODONTACEÆ (5)
7. Primary stems creeping, secondary stems erect and large, dendroid; sporophytes clustered.....CLIMACIACEÆ (7)
7. Primary stems prostrate or ascending; sporophytes single..... 8
8. Costate; sporangium erect, basal membrane short.....ENTODONTACEÆ (6)
8. Costate; sporangium usually inclined or curved, basal membrane broad.... 9
9. Cilia wanting; scales cells large; calyptra mitrate.....HOOKERIACEÆ (4)
9. Cilia present; scales cells small; calyptra cucullate.....10
10. Costa double or furcate, short or lacking; not complanate; lid long-beaked.....SEMATOPHYLLACEÆ (10)
10. Costa single, or if double then plants complanate or with a conic or short rostrate lid.....11
11. Costa single and reaching beyond the middle; usually glossy; often complanate, not secund.....BRACHYTHECIACEÆ (11)
11. Costa usually short and double, sometimes wanting; if single then plants not glossy, scales often secund.....HYPNACEÆ (10)

1. *FONTINALACEÆ.*

Aquatic mosses, long and floating, dark; scales smooth, basal cells orange.

1. FONTINÀLIS (L.) Hedw.

Scales ecostate, 3-seriate; sporangium almost immersed, oval to ovate, peristome orange to brownish.

1. Scales keeled, making the gametophore appear triangular..... *F. antipyretica*
1. Scales not keeled, but concave..... 2
2. Alar cells distinctly differentiated; summer scales different from those of the spring..... *F. biformis*
2. Alar cells not at all or only indistinctly differentiated..... 3
3. Perichaetial scales rounded at the apex, lacerate..... *F. delmarei*
3. Perichaetial scales pointed at the apex, sometimes finely lacerate; branches attenuate..... *F. delecarlica*

1. *F. antipyrética* var. *gigantea* Sull. (*F. gigantea* Sull.) Dark brownish to golden-green, irregularly branched; scales carinate, ovate-lanceolate to ovate, entire, acute; sporangium sub-sessile, emergent; peristome reddish. Summer. On wood or stones in running water. Adams, Hocking.

2. *F. delmarei* Ren. Card. Dull green, naked below, irregularly pinnate upper scales dense, oblong-lanceolate, erect-spreading, very concave sporangium sub-emergent. Running water. Auglaize, Portage.

3. *F. delecárlica* Br. & Sch. Slender, much branched, branches attenuate at the ends, dull, naked below; scales erect-spreading, oblong-lanceolate to lanceolate, entire or slightly toothed near the apex, concave, somewhat involute; sporangium immeresd. Summer. On stones in running water. Hocking.

4. *F. bifórmis* Sull. Dark or yellowish-green, branches dense; alar cells distinctly differentiated, summer scales differing from those of spring in being smaller and narrower, convolute above, rigid; sporangium oblong-ovate; lid conic-rostrate. Streams. Portage. ("bei Columbus in Ohio," Engler and Prantle; "Central Ohio," Lesq. and Jas.)

2. *NECKERACEÆ.*

Loosely cespitose, rather stiff and robust, primary stems creeping, secondary stems pinnately branched, erect or pendent, complanate; sporangium erect, actinomorphic.

1. NÈCKERA Hedw.

Scales ecostate, smooth; inner membrane low, cilia none; calyptra with erect hairs; annulus lacking.

1. *N. pennàta* (L.) Hedw. (*Fontinalis pennata* L.) Branches 2–3 in. long; scales acute, ovate-lanceolate, strongly undulate, entire or obscurely denticulate above, costa none or very faint; sporangium immersed, teeth sometimes apically united; calyptra small. Summer. On trunks of deciduous trees, sometimes on rocks. Champaign, Lake.

3. *HEDWÍGIACEÆ.*

Cespitose, irregularly branched with pendent branches; scales pleuriseriate, inbricated when dry, ecostate, those on the primary stalks recurved; sporangium erect, short.

1. HEDWÍGIA Ehrh.

Lax, glaucous-green above; scales entire, revolute, hyaline tipped, median basal cells yellowish; sporangium immersed, pale brown, mouth red.

1. *H. ciliàta* Ehrh. (*H. albicans* Lindb.; *Fontinalis albicans* Web.; *Anictangium ciliatum* Hedw.) Blackish below, gametophores ½–3 in. long; scales ecostate; peristome wanting. Spring. Tree trunks or noncalcaeous rocks. Butler, Clark, Fairfield, Franklin, Lake, Lawrence, Montgomery, Morgan, Scioto, Shelby.

4. *HOOKERIACEÆ.*

Small irregular, sparingly branched; scales loosely imbricated, perichaetial branch, rooting; sporangium arcuate, sub-erect to horizontal, peristome double, hypnoid, teeth lanceolate, subulate, closely articulate.

HOOKÉRIA Tayl.

Procumbent; scales acuminate, bicostate, areolation loose; outer peristome purplish, inner one orange with a basal membrane, calyptra almost entire.

1. H. sullivántii C. Muell. Ms. (*H. acutifolia* Sull.) Scales ovate oblong, acute, entire, yellowish-green; fruit not known. Fairfield.

5. *LEUCODONTACEÆ.*

Stiff and robust mosses, laxly cespitose, mostly shining; primary stem creeping, radiculose, secondary stems erect, ascending or pendent; scales dense, decurrent, acute; sporangium erect, actinomorphic; peristome double, basal membrane short, cilia none; lid conic, rostrate deciduous.

1. Costa double or none, calyptra smooth.....*Leucodon*
1. Costa single; calyptra hairy.....*Forsstroemia*

1. LEÙCODON Schwaeg.

Secondary stems numerous, often pendent and curved outward; scales many-ranked, concave, margins recurved, closely imbricated when dry; inner peristome rudimentary, lid entirely covering the sporangium.

1. Scales ovate-elliptical, short-acuminate; sporangium exserted...*L. julaceous*
1. Scales ovate-lanceolate, longer acuminate; sporangium emergent..*L. brachypus*

1. *L. brâchypus* Brid. Brownish to light green, ¼–2 in. long; scales plicate, entire or serrulate above; slightly secund; sporangium brown, dark-rimmed; lid obliquely rostrate. Late fall or winter. Trees and rocks. "Northern Ohio," H. C. Beardslee's catalog.

2. *L. julàceous* (L.) Sull. (*Hypnum julaceum* L.; *Pterigynandrum julaceum* Hedw.) Smaller than the preceding, julaceous when dry; never secund, scales concave, scarcely plicate, serrulate in the upper part. Fall. On tree trunks. Champaign, Clark, Fairfield, Franklin, Lake, Montgomery, Perry.

2. FORSSTRÒEMIA Lindb. (*Leptodon* Mohr.)

Green to brownish-green, usually dull; scales erect-spreading when moist, imbricated when dry, margin revolute, entire, or serrate near the apex; inner peristome none or rudimentary; lid with erect hairs.

1. Scales ecostate; sporangium scarcely exserted.....*F. trichomitrium*
1. Scales costate; sporangium plainly exserted.....*F. ohioensis*

1. *F. trichomîtria* (Hedw.) Lindb. (*Leptodon trichomitrium* Mohr.; *Pterigynandrum trichomitrium* Hedw.) Loosely cespitose, 1–2 in. long, much branched, dull; scales dense, concave, serrate near the apex; sporangium brown, emergent. Winter. On tree trunks. Champaign, Clark, Lake, Morgan.

2. *F. ohioênsis* (Sull.) Lindb. More slender and with fewer branches than the preceding; scales costate; sporangium brown, hypophysis long, lid curved rostrate. Spring. On trees. Franklin.

6. *ENTODONTACEÆ.*

Loosely cespitose, medium to large, rather robust; scales dense, smooth or slightly papillose, costa short and double or entirely wanting; sporangium erect, straight, exserted, smooth; cilia usually lacking, calyptra smooth.

1. Cells of the scales papillose.....*Schwetschkeopsis*
1. Scales smooth..... 2
2. Robust; yellow-green; scales concave, narrowed at the base.....*Entodon*
2. Slender, dark green; scales not narrowed..... 3
3. Scales acuminate, margins plane; branches curved at the tips.....*Pylaisia*
3. Scales acute, margins revolute; branches not curved at the tips..*Platygyrium*

1. SCHWETSCHKEÓPSIS Broth.

Cespitose, branches slender, yellowish-green; scales dense, concave, imbricated when dry, plicate, plane, acuminate; peristome teeth yellow, basal membrane one-third the height of the teeth, cilia rudimentary.

1. *S. denticulàta* (Sull.) Broth. (*Leskea denticulata* Sull.) Soft, flat tufts ½–1 in. deep, irregularly branched, flattened; scales ovate, denticulate, ecostate, seta yellowish-red, sporangium oblong, cilia wanting, lid conic-rostrate. Bases of trees or on rocks. Clark.

2. ÉNTODON C. Muell. (*Cylindrothecium* Br. & Sch.)

Yellowish-green, loosely cespitose, glossy, prostrate to ascending, pinnately branched; scales usually imbricated dorsally, spreading laterally, costa short and double or wanting, alar cells quadrate, hyaline, sporangium cylindrical straight, cilia lacking, basal membrane low.

1. Scales gradually acuminate.....*E. brevisetus*
1. Scales acute or abruptly acuminate, apiculate..... 2
2. Branches usually terete or julaceous.....*E. seductrix*
2. Branches usually flattened..... 3
3. Scales acute but not acuminate; teeth with more than 20 articulations, *E. compressus*
3. Scales acuminate-apiculate, teeth with less than 20 articulations, *E. cladorhizans*

1. *E. sedúctrix* (Hedw.) C. Muell. (*Neckera seductrix* Hedw.; *Cylindrothecium seductrix* Sull.) Robust, 1 in. or more long; scales appressed, oblong elliptical to ovate-apiculate, tip often reflexed, margin plane, entire or obscurely denticulate near the apex; seta purple, sporangium golden-brown, hypophysis abrupt, peristome inserted below the mouth, teeth papillose. Autumn. Rotten wood, rocks, bases of trees, and soil. Clark, Fairfield, Franklin, Greene, Hamilton, Hardin.

2. *E. brevisètus* (Hook. & Wils.) Jaeg. (*Cylindrothecium brevisetum* Wils.) Soft slender; scales acuminate, long; seta three-eighths to one-half in. long, copper-colored; sporangium golden-brown, neck tapering, segments of the inner peristome adherent to the teeth; lid small, obliquely rostrate. Autumn. On logs. Champaign, Clark.

3. *E. cladorhizans* (Hedw.) C. Muell. (*Cylindrothecium cladorhizans* Schimp.; *Neckera cladorhizans* Hedw.). Large flattened tufts, very glossy; scales oblong-ovate, faintly serrulate near the apex, apex often reflexed; teeth not papillose; seta castaneous, lustrous, base of the sporangium abrupt. Autumn and early winter. On logs. Clark.

4. *E. compréssus* (Hedw.) C. Muell. (*Cylindrothecium compressum* Br. & Sch.). Gametophores much compressed, more slender than the last species; scales entire; sporangium ovate to elliptical, short, lid curved, rostrate, peristome teeth closely articulate, papillose. Autumn and early winter. Bases of trees. Franklin.

3. PLATYGYRIUM Br. & Sch.

Cespitose in flat mats, dark to bright green; scales decurrent, acute to acuminate, ecostate; lid conic.

1. *P. rèpens* (Brid.) Br. & Sch. (*Pterogonium repens* Schwaeg.; *Anomodon repens* Fuern.; *Cylindrothecium repens* DeNot). Primary stems creeping, radiculose below, branches short, julaceous; scales imbricate when dry, margins revolute below; seta about ¾ in. long, copper-colored, lustrous, sporangium golden brown, cylindrical, hypophysis tapering, teeth hyaline bordered. Autumn. Tree trunks and decaying wood. Champaign, Clark, Franklin, Lake.

4. PYLAÏSIA Br. & Sch.

Flatly cespitose, branches short and curved at the tips when dry; scales imbricated when dry, erect-spreading and secund when moist, concave, ovate to ovate-lanceolate, acuminate, costa double and very short or none; seta ¼–½ in. long, sporangium erect, cylindric, cilia none, segments often adherent to the teeth.

1. Segments of endostome free from the teeth, membrane distinct; operculum beaked.....*P. subdenticulata*
1. Segments adherent to the teeth, lid conic; membrane low or wanting..... 2
2. Segments completely adherent; quadrate alar cells few.....*P. intricata*
2. Segments partly adherent; quadrate cells bordering one-third of the scales.....*P. schimperi*

1. *P. intricàta* (Hedw.) Ren. & Card. (*P. velutina* Br. & Sch.; *Pylaisiella velutina* Lindb.; *Pterygynandrum intricatum* Hedw.). Light, flat, dense mats; scales lanceolate, long-acuminate, falcate-secund, ecostate; seta straight, light brown, about three-sixteenths inches long; sporangium ovoid-cylindric, castaneous. Autumn. On stumps and bases of trees. Champaign, Clark, Franklin.

2. *P. schimperi* Card. (*P. intricata* Br. & Sch.; *Pylaisiella intricata* Grout). Thin dense mats, dark green; scales dense, decidedly falcate-secund, ovate-lanceolate, long-acuminate, alar cells yellowish, incrassate; seta about ½ in. long, reddish; sporangium ovoid-oblong, small-mouthed. Autumn. Tree trunks and decaying wood. Clark, Lake, Perry.

3. *P. subdenticulàta* Br. & Sch. (*Pylaisia denticulata* Sull.). Yellowish-green, flat mats, much branched; scales ovate-lanceolate, ecostate, or costa very faint and short, entire below, sub-denticulate above; sporangium oblong. Autumn. Tree trunks, wood and stones. Clark.

7. *CLIMACIACEÆ.*

Large mosses, with erect branches from a creeping caudex, dendroid; scales 3 or more ranked, smooth, rarely slightly papillose at the angles; sporophytes clustered, peristome with articulate teeth, segments of the inner peristome carinate, often split along the keel.

1. Sporangium erect and actinomorphic; peristome without cilia.....*Climacium*
1. Sporangium curved, cernuous; peristome with cilia.....*Thamnium*

1. CLIMÀCIUM Web. & Mohr.

Large, tree-like, branchlets simple and clustered near the top of the main erect branch, papaphyllia numerous; scales decurrent, auricles lanceolate, acute, sharply serrate in the outer portion; sporangium cylindric, castaneous, teeth with a dark red border, inner peristome orange, calyptra long, enclosing the sporangium, split at one side.

1. *C. americànum* Brid. Loosely cespitose, 2–5 in. deep, yellowish-green, lustrous, primary branches erect bearing ovate, closely imbricated scales below and a tuft of branchlets above; branch scales broad lanceolate, serrate in the outer portion, erect-spreading, imbricated when dry, costa strong, almost to the apex; seta erect, 1–1½ in. long, castaneous, sporangium erect or slightly curved, slightly constricted below the mouth when dry, lid slender rostrate. Autumn. Soil, rocks, and logs in swamps. Adams, Champaign, Clinton, Franklin, Galion, Hancock, Meigs, Montgomery, Ottawa, Portage, Richland, Ross, Scioto, Seneca, Shelby, Stark, Summit, Vinton, Williams.

2. THÁMNIUM Br. & Sch.

Robust mosses with erect branches, tree-like, with a cluster of branchlets at the top, spreading, curved; scales erect-spreading, serrate, costa strong, ending below the apex; seta red, smooth sporangium inclined to horizontal, somewhat arcuate, gibbous peristome yellow, teeth bordered, lid, conic-rostrate, calyptra cucullate.

1. *T. allegheniênsis* (C. Muell.) Br. & Sch. (*Hypnum allegheniensis* C. Muell.; *Porotrichum allegheniensis* Grout). Large, 1½–3 in. deep, bright or pale green, lustrous: scales oblong-elliptical, short acuminate, or acute base narrow, margin plane, sharply serrate in the outer portion; seta about ½ in. long, sporangium castaneous, oblong cylindric, lid one-third to one-half as long as the urn. Autumn. Dripping ledges in ravines. Greene, Lake.

8. *LESKEACEÆ.*

Cespitose, usually dull and stiff; scales rarely uniform, usually costate; basal portions smoother than the outer.

1. Primary stems stoloniferous; archegonial clusters borne on the branches.... 2
1. Not stoloniferous; archegonial clusters borne on the main stems..... 3
2. Slender mosses; costa ending at or below the middle of the scale, *Haplohymenium*
2. More or less robust mosses; costa reaching nearly or quite to the apex, *Anomodon*
3. Costa single, strong, nearly or quite to the apex..... 4
3. Costa short, single or double or lacking..... 8
4. Scales of primary stems and branches similar; 2–4 or no papillæ on the terminal cell..... 5
4. Scales of primary stems and branches dissimilar; one papilla on the terminal cell..... 7
5. Sporangium erect or nearly so; cilia rudimentary.....*Leskea*
5. Sporangium arcuate; cilia complete..... 6
6. Cells smooth or slightly papillose; cilia smooth.....*Elodium*
6. Cells strongly papillose on both surfaces; cilia nodose or appendiculate, *Haplocladium*
7. Medium-sized mosses; paraphyllia branched; cells with 2–5 papillæ on each surface; lid short-rostrate.....*Rauia*
7. Paraphyllia simple or if branched then large mosses, lid long-rostrate, *Thuidium*
8. Irregularly bushy branched; costa wanting or very short; cilia two..*Myurella*
8. Pinnately simple branched; costa distinct; cilia none.....*Thelia*

1. THÈLIA Sull.

Densely cespitose, dull, glaucous, julaceous, creeping, branches closely pinnate; scales imbricated, concave, broadly ovate, margins with long slender teeth, costa short, cells each with one large dorsal papilla; perichaetial scales with long marginal cilia, oblong; seta slender, reddish; sporangium erect, actinomorphic, inner peristome with a basal membrane and short segments.

1. Papillæ simple, curved.....*T. hirtella*
1. Papillæ branched or forked..... 2
2. On trees; scales ciliated.....*T. asperella*
2. On soil; scales not ciliated.....*T. lescurii*

1. *T. hirtèlla* (Hedw.) Lindb. (*Pterigynandrum hirtellum* Hedw.; *Hypnun hirtellum* C. Muell.) Thin mats, light above, radiculose below; scales sub-orbicular, margins spinulose-dentate above, ciliate below, abruptly acuminate, lid rostrate. Autumn. Tree trunks and roots. Champaign, Clark, Franklin, Lake, Montgomery.

2. *T. asperèlla* Sull. (*Leska asprella* Br. & Sch.) Light glaucous green; scales long-ciliate, long-acuminate; seta red, about ½ in. long; sporangium oblong cylindric, pale; peristome whitish. Autumn. Tree bases. Clark, Franklin, Montgomery, Ottawa.

3. *T. lescùrii* Sull. Fasciculately branched, light claucous green; scales short-acuminate; seta reddish, over ½ in. long; sporangium reddish-brown. Autumn. On sandy soil and rocks. Not reported, but is probably to be found.

2. MYURÉLLA Br. & Sch.

Soft loose mats of very slender branches, irregularly branched, light to bright bluish-green, sometimes flagellate at the apex; scales imbricate, concave, broad-ovate, smooth or dorsally mamillate; seta red, sporangium erect or slightly inclined when old, constricted below the mouth, cilia present.

1. Scales serrulate-dentate; obtuse or short-apiculate.....*M. julaceae*
1. Scales spinulose-dentate abruptly long-acuminate.....*M. gracilis*

1. *M. julàcea* (Vill.) Br. & Sch. (*Hypnum julaceum* Vill.) Light green, branches filiform, julaceous; scales dense, imbricated, costa indistinct; sporangium rarely found, oblong-elliptical; peristome yellow. July-August. In crevices of rocks. Not reported.

2. *M. grâcilis* (Weinm) Lindb. (*M. careyana* Sull.) Pale, glaucous-green; scales not so dense and more spreading than in the preceding species; papillæ large and simple, costa short; rarely fruiting. Damp crevices in limestone. Cuyahoga, Greene.

3. HAPLOYMÈNIUM Doz. & Molk.

Stiff, stems creeping with pinnate branches forming a thin mat; upper scales spreading to squarrose, imbricated when dry; base of scales concave, clasping, more or less abruptly narrowed, broadly ligulate, entire, costa to the middle of the scale or beyond; sporangium brown, erect.

1. *H. trîstes* (Cesat. Lindb.) (*Leskea tristis* Cesat.; *Anomodon tristis* Sull.) Small, mats thin, very slender, dull green, irregularly pinnate; scales imbricated when dry, spreading-squarrose when moist, blunt, several papillæ on each face of the cell; fruit not yet found. Champaign, Clark, Lake.

4. ANOMÓDON Hook. & Taylor.

Coarse, robust, lax mats, dull; primary stems creeping, secondary erect to ascending; scales dense, plane, densely papillose on both surfaces; costa simple and strong; seta erect, sporangium erect, not narrowed below the mouth.

1. Branches attenuate ..... *A. attenuatus*
1. Branches not attenuate 2
2. Scales norrowly acuminate, ending in a hair point ..... *A. rostratus*
2. Scales ligulate from a broader base 3
3. Scales apiculate, auricled ..... *A. apiculatus*
3. Scales with rounded apex, not auricled ..... *A. minor*

1. *A. apiculàtus* Br. & Sch. (*Leskea apiculata* Schimp.; *Hypnum rugelii* C. Muell.) Somewhat glaucous, reddish-brown below, stems 1–2 in. long, upper margins involute, entire, crisped when dry, costa ending below the apex; seta about ¼ in. long, brown; sporangium ovate-cylindrical, castaneous; peristome segments rudimentary, basal membrane low. Autumn. On shaded rocks and bases of trees. Lake.

2. *A. mìnor* (Hedw.) Fuern. (*A. obtusifolius* Br. & Sch.) Branches 1–2 in. long, claucous, brownish when old; scales somewhat complanate, entire, densely papillose, costa strong, ending below the apex; seta ¼ -½ in., sporangium cylindric-oblong, mouth contracted, lid conic, oblique-rostrate, peristome hyaline. Late autumn and winter. Bases of trees and rocks. Clark, Franklin, Lake.

3. *A. attenuàtus* (Schreb.) Hueben. (*Leskea attenuata* Hedw.; *Hypnum attenuatum* Schreb.) Slender mosses, more densely tufted than the two preceding species, wide, many branches flagellate; scales lanceolate, acute, minutely apiculate, costa ending below the apex; seta about ⅜ in., brown, sporangium cylindric, castaneous, peristome segments narrow. Autumn. Rocks, trees, stumps in the shade. Belmont, Clark, Fairfield, Hamilton, Hancock, Lake, Seneca.

4. *A. rostràtus* (Hedw.) Schimp. (*Leskea rostrata* Hedw.) Wide, dense tufts of very slender branches, yellowish-green; scales long-acuminate complanate, margins often recurved; seta ¼–⅜ in., brown; sporangium oblong-ovoid, brown, short; lid conic, basal membrane high. Autumn. On rocks and at the bases of trees. Clark, Fairfield, Franklin, Portage, Seneca, Union, Williams.

5. LÉSKEA Hedw.

Small, loosely cespitose, dark green mosses, stalks prostrate with short erect branches; scales dense, imbricated when dry, sporangium oblong-cylindrical, cilia rudimentary or none, basal membrane low; calytra smooth, cucullate.

1. Scales ovate-lanceolate, acute to long-acuminate, somewhat secund, *L. polycarpa*
1. Scales ovate, acute to obtuse, not secund 2
2. Scales revolute, 2-plicate ..... *L. gracilescens*
2. Scales plane, non-plicate ..... *L. obscura*

1. *L. polycârpa* Ehre. Hedw. (*Hypnum medium* Dicks.) Mats thin, dull green; scales loosely imbricated when dry, entire, basal margins recurved, apex often obliquely pointed; seta about ⅓ in., sporangium light brown. Summer. Bark, wet wood or stones or damp earth. Ashtabula, Franklin, Montgomery, Morgan.

2. *L. gracilèscens* Hedw. Branches erect, simple, numerous; scales closely imbricated when dry, acute, entire; peristome whitish. Early summer. Moist tree bases and wood. Not reported.

3. *L. obscura* Hedw. (*L. nervosa* Sull.; *L. microcarpa* Schimp.) Erect branches, divided and fewer than in the preceding species; scales spreading when moist, incurved, appressed when dry, apex sub-acute to obtuse, concave, entire or serrulate; seta ½–¾ in., peristome yellowish. Early summer. Wet stones, logs and roots of trees. Lake, Morgan.

6. RÀUIA Aust.

Dull, dark green, pinnately branched, julaceous; scales erect-spreading, imbricated when dry, stem scales triangular to cordate, entire, long-acuminate, branch scales ovate-lanceolate, appressed, pale, seta slender, reddish; sporangium light brown, inner peristome with wide basal membrane, lid conic, short-rostrate.

1. *R. scìta* Aust. (*Hypnum scitum* Beauv.; *Thuidium scitum* Aust.) Densely pinnate; sporangium oblong-cylindrical, straight or slightly arcuate, erect or inclined. Teeth pale. Autumn and winter. Bases of trees. Clark, Erie.

2. *R. scita aestivàle* (Lesq. & Jas.) (*Thuidum aestivum* Aust.; *T. scitum* var. *aestivale* Aust.; *Hypnum scitum aestivale* Lesq. & Jas.) Less densely branched sporangium, horizontal, teeth yellowish, sporangium abruptly and very short rostrate. Bases of trees. Autumn and winter. Clark, Erie.

7. HAPLOCLÀDIUM C. Muell.

Thin mats, dull, creeping pinnately branched, branches usually simple, ascending; scales erect-spreading when moist, appressed when dry; paraphyllia branched, numerous; scales lanceolate to lance-subulate, base revolute, upper part faintly serrate to entire, costa strong, almost or quite to the tip, acute to acuminate; seta ⅛–⅓ in. long, reddish; sporangium inclined to horizontal, more or less arcuate, contracted below the mouth when dry, peristome yellow, cilia complete, calyptra conic.

1. Scales ovate, abruptly rounded, short-acuminate.....*H. virginianum*
1. Scales ovate, gradually long-acuminate.....*H. microphyllum*

1. *H. virginiànum* (Brid.) Broth. (*Thuidium virginianum* Lindb.; *Hypnum gracile* var. *lancastriense* Sull. & Lesq.; *Thuidium gracile lancastriense* Card.) Dark green; scales ovate, concave, serrulate in the outer part, erose-dentate below, costa into the acumen; perichaetial scales light, lanceolate; seta castaneous, sporangium castaneous, curved, constricted below the mouth when dry; lid short-beaked. Spring. Ground or roots of trees in the open woods. Reported from Ohio by Lesquereux.

2. *H. microphyllum* (Sw.) Broth. (*Hypnum gracile* Br. & Sch.; *Thuidium microphyllum* Best; *Thuidium gracile* Br. & Sch.) Pale or yellowish-green; pinnately branched; scales ovate to lance-ovate, margins entire or sinuate-dentate, costa almost to the tip; seta about ¾ in. long, castaneous, sporangium light brown, oblong, curved, lid short-conic. Earth, rotten wood, stones and tree bases. Summer. Clark.

8. THUÍDIUM Br. & Sch.

Slender to robust, stiff, dull to light green, pinnately branching to form frond-like gametophores; scales erect-spreading when moist, incurved or appressed when dry, plicate, base narrow and recurrent, branch scales lance-ovate, perichaetial scales paler, lanceolate; sporangium more or less arcuate, constricted below the mouth when dry; seta slender, red or castaneous; lid conic, oblique rostrate; calyptra cucullate.

1. Plants less than 2 in.; paraphyllia unbranched, few 2
1. Plants over 2 in.; paraphyllia numerous, branched 3
2. Branches papillose; ⅛–¾ in. tall ..... *T. pygmaeum*
2. Branches smooth; ⅛–1⅜ in. tall ..... *T. minutulum*
3. Simply pinnately branched; erect or ascending in tufts 4
3. Bipinnately branched; prostrate in mats 5
4. Plants rigid; on dry stones or sterile soil; apical cell of the branch scale papillose ..... *T. abietinum*
4. Plants soft on wet swampy soil; a spical cell of the branch scale not papillose ..... *T. blandowii*
5. Scales recurved, spreading when moist, margin plane, costa percurrent, *T. recognitum*
5. Scales erect-spreading when moist, margin revolute, costa ending below the apex ..... *T. delicatulum*

1. *T. pygmàeum* Br. & Sch. (*Hypnum pygmaeum* Sull.) Delicate, ⅛–½ in., creeping, forming delicate patterns over the substratum, branches papillose, paraphyllia on the branches; scales triangular-ovate; seta ¼–½ in., sporangium oblong-ovate, calyptra oblique-rostrate. Late summer and early autumn. Rocks and earth in moist shade. Ashtabula, Clark, Franklin.

2. *T. minùtulum* (Hedw.) Br. & Sch. (*Hypnum minutulum* Hedw.) Irregularly branched, branches smooth, paraphyllia on the branches and main stems; stem scales distant, deltoid, acuminate, costa to near the apex, branch scales ovate-acuminate, costa shorter, perichaetial scales lanceolate; seta about ¾ in., copper-colored, sporangium ovate-oblong, cernuous, operculum oblique-rostrate. Autumn. Rotten wood and bases of trees. Clark.

3. *T. delicàtulum* (L.) Mitt. (*Hypnum delicatulum* L.) "Common Fern Moss." Thick mats, bright green at the tips of the gametophores, darker below, bipinnately or tripinnately branched, forming fronds, procumbent; stem scales triangular, margins somewhat recurved, erect-spreading when moist, appressed when dry, serrate, acuminate, margins somewhat recurved; branch scales broad-ovate, smaller; perichaetial scales ciliate on the margins; seta 1–1½ in. long, lustrous, castaneous; sporangium oblong, arcuate, castaneous, operculum conic-rostrate. Winter. Soil, rocks or wood in moist woods. Champaign, Lake, Vinton.

4. *T. recògnitum* (Hedw.) Lindb. (*Hypnum recognitum* Hedw.; *Thuidium delicatulum* Br. & Sch.) Yellowish-green, mostly bipinnately branched, stem-scales broadly deltoid, auricled, cordate, abruptly acuminate, spreading-recurved when moist, sulcate when dry, margins usually plane; perichaetial scales without cilia; seta 1–1½ in long, lustrous sporangium oblong, arcuate, castaneous, lid short-rostrate.

Summer. Soil, wood, and rocks in moist woods. Champaign, Clinton, Fairfield, Franklin, Licking, Lawrence, Logan, Morgan, Summit.

5. *T. abietínum* (L.) Br. & Sch. (*Hypnum abietinum* L.) "Wiry Fern Moss." Large stiff mosses forming loose mats 2–3 in. deep, simple pinnate; paraphyllia short, dark green; stem scales ovate, acuminate, biplicate, serrulate, recurved, appressed when dry, costa to ¾ the length of the scale; sporangium narrow, cylindric, cernuous. Not seen in fruit. On dry rocky ledges and sterile soil. Not reported from Ohio.

6. *T. blandowii* (Web. & Mohr.) Br. & Sch. (*Hypnum blandówii* Web. & Mohr.) Pale or yellowish-green, in soft loose mats, 2–4 in. deep, paraphyllia long and branched, numerous, gametophores simply pinnate, branches slender; stem scales acuminate, ovate-deltate, dense, thin, costa ½ the length of the scale; seta copper-colored, 1½–2 in. long; sporangium curved, oblong-cylindric, contracted below the mouth when old, lid conic. Summer. Wet swampy soil. Reported by Sullivant from "Ohio."

9. ELÒDIUM (Sull.) Warnst.

Large yellowish-green to brownish mosses, simple or pinnately branching; scales erect-spreading when moist, appressed when dry, concave, plicate, acuminate, revolute, costa ending below the apex; perichaetial scales narrow, erect; sporangium arcuate, oblong-cylindrical, brown, peristome yellow, teeth confluent at the base, hyaline bordered, basal membrane high, lid conic, calyptra cucullate.

1. *E. paludòsum* (Sull.) Loeske. (*Hypnum paludosum* Sull.; *Thuidium paludosum* Jaeg. & Sauer.) Irregularly pinnate, yellowish-green, creeping, branches erect or ascending, 1–1½ in. long; scales oblong-lanceolate, only slightly papillose, paraphyllia numerous, branched; seta ½–1 in. long, reddish, sporangium inclined to horizontal, about 3 to 1; operculum apiculate. Winter. Swampy ground. Fulton.

9. *FABRONIACEÆ.*

Bright or light green, cespitose, red radiculose, small soft mosses; scales dense, appressed when dry, non-plicate, erect-spreading when moist, ovate to lanceolate; sporangium exserted, erect, actinomorphic, ovoid to short-cylindrical; calyptra cuculiate, smooth.

1. Scales with simple costa; inner peristome of filiform divisions...*Anacamptodon*
1. Scales ecostate; inner peristome wanting.....*Habrodon*

1. ANACÁMPTODON Brid.

Scales somewhat secund, ovate, long-acuminate, entire, costa to above the middle, oblong; sporangium with short neck, constricted below the mouth when dry; inner peristome without basal membrane.

1. *A. splachnoìdes* (Froel.) Brid. (*Campylodontium hypnoides* Schwaeg.; *Neckera splachnoides* Schwaeg.) Bright green, seta and sporangium reddish-brown, teeth lighter brown, in pairs, reflexed when dry. Early summer. On moist decaying wood or decaying places in living trees. Clark.

2. HÁBRODON Schimp.

Creeping, irregularly branched, leafy branches julaceous; scales entire or slightly crenulate, cell walls thick; sporangium ovoid.

1. *H. purpusíllus* (DeNot) Lindb. (*H. notarisii* Schimp.) "Tree trunks in central Ohio." Reported by W. S. Sullivant (L. & J. Manual). No specimen in the herbarium.

10. *SEMATOPHYLLACEÆ.*

Cespitose, often lustrous, creeping to ascending, irregularly branched; scales pleuriseriate, costa double, very short or none, one row of basal cells inflated; inner peristome free, basal membrane high; antheridial clusters gemmiform.

1. RAPHIDIOSTÈGIUM (Br. & Sch.) DeNot.

Densely cespitose, creeping, irregularly pinnately branched; scales erect-spreading, non-plicate, concave, ecostate or costa double and very short; sporangium suberect to horizontal, peristome hypnoid, calyptra long-subulate-rostrate, teeth yellowish, hyaline-bordered.

1. Plants on trees; sporangium erect or nearly so; scales secund....*R. adnatum*
1. Plants on stones; sporangium inclined to horizontal, scales erect-spreading or slightly secund.....*R. caroliniamum*

1. *R. adnàtum* (Mx.) Br. & Sch. (*Leskea adnata* Mx.; *Rhyncostegium microcarpum* Jaeg.; *Hypnum microcarpum* C. Muell.; *Sematophyllum adnatum* E. G. Britt.) Small, thin mats, green to golden-green, branches often curved, short, suberect; scales dense, imbricated when dry, oblong-lanceolate, short-acuminate, margin reflexed, almost entire; sporangium erect, not at all or only slightly zygomorphic, oblong-ovate, mouth reddish, slightly constricted below, castaneous, seta about ¼ in. long. Summer and early autumn. Champaign.

2. *R. carolinànum* (C. Muell.) Jaeg. (*Hypnum carolinianum* C. Muell.; *Sematophyllum carolinianum* E. G. Britt.; *Hypnum demissum* Wils var. *carolinianum* Lesq. & Jas.) Dark yellowish or dirty green, small tufts, branches ascending to erect; scales imbricated, sub-secund or complanate, non-plicate, ovate-lanceolate, slightly serrulate near the apex, margins reflexed; seta castaneous, about ½ in. long, sporangium curved, constricted below the mouth when dry, mouth red. Summer and early autumn. Wet, non-calcareous rocks in ravines. Clark, Summit.

11. *BRACHYTHECIACEÆ.*

Creeping, branches procumbent or ascending; scales erect-spreading to appressed, often complanate, sometimes secund; stem and branch scales unlike, plicate or sulcate, ovate to lanceolate, acuminate, alar cells often hyaline, not inflated, paraphyses filiform; sporangium ovoid, cernous, lid conic to long-rostrate, antheridia in gemmiform clusters.

1. Sporangium erect and actinomorphic ..... *Homalotheciella*
1. Sporangium inclined to horizontal, zygomorphic 2
2. Scales deeply grooved ..... *Camptothecium*
2. Scales not at all or only slightly grooved 3
3. Alar cells differentiated; lid conic ..... *Brachythecium*
3. Alar cells few or none; lid long-beaked 4
4. Cells elongated, rhomboidal or hexagonal, somewhat rough ..... *Brynhia*
4. Cells short, smooth 5
5. Complanate; seta smooth ..... *Rhynchostegium*
5. Scales spreading or imbricated; seta usually rough 6
6. Scales very concave; abruptly piliferous-acuminate ..... *Cirriphyllum*
6. Scales plane or slightly concave; gradually acuminate, not piliferous 7
7. Plicate, usually somewhat concave ..... *Eurynchium*
7. Non-plicate, plane or only slightly concave, seta smooth in our species, *Oxyrynchium*

1. HOMALOTHECIÉLLA (Card.) Broth.

Small, soft, glossy mosses, loosely cespitose with creeping stems, branches short, numerous, curved at the ends when dry; scales erect-spreading when moist, imbricated when dry, concave, non-plicate, lanceolate to acuminate, costa simple, alar cells green, quadrate; seta castaneous, rough; inner peristome shorter than the outer, yellow, cilia none; lid long-rostrate.

1. *H. subcapillàta* (Hedw.) Broth. (*Homalothecium subcapillatum* Sull.) Light yellowish green mats; scales smooth, costa ending near the middle, abruptly long-acuminate, somewhat serrate above, alar cells extending up ⅓ of the margin; sporangium slightly curved and constricted below the mouth, somewhat gibbous, peristome teeth red with a median pellucid line, segments adhering to the teeth. Autumn. Tree trunks and logs in the woods. Clark.

2. CAMPTOTHÈCIUM Br. & Sch.

Large, loosely cespitose, yellowish-green glossy mosses; gametophores branching pinnately; scales erect-spreading when moist, concave, strongly plicate, ovate-lanceolate, acuminate, serrulate, costa simple, alar cells quadrate; seta castaneous, usually rough, sporangium cernuous, gibbous; peristome teeth confluent, bordered, inner peristome free, the same length as the outer.

1. *C. nìtens* (Schreb.) Schimp. (*Hypnum nitens* Schreb.) Bright yellowish, lustrous, with brown felted radicles 2–3 in. tall; scales elongate-lanceolate, margins revolute, alar cells few, somewhat secund; sporangium arcuate. Late spring. Wet, swampy soil. Reported from southern Ohio by Lesquereux. No specimen in the herbarium.

3. BRACHYTHÈCIUM Br. & Sch.

Wide flat mats, creeping or almost procumbent; scales dense, stem scales erect-spreading to spreading, plicate, lanceolate, acuminate, margins plane, costa simple, alar cells quadrate to somewhat elongated, not well defined: sporangium cernuous, gibbous, horizontal, ovate to oblong, dark colored; peristome teeth confluent at the base, inner peristome free, yellowish, basal membrane wide, cilia nodose or appendiculate, lid conic.

1. Seta smooth 2
1. Seta rough, at least above 5
2. Scales not plicate or striate; lanceolate to lance-ovate ..... *B. acutum*
2. Scales plicate, ovate-lanceolate to ovate 3
3. Sporangium erect, straight or nearly so; cilia rudimentary or lacking, *B. acuminatum*
3. Sporangium more or less inclined; cernuous; cilia well-developed 4
4. Sporangium sub-erect; only slightly curved, 3–4: 1 ..... *B. oxycladonm*
4. Sporangium strongly inclined; much curved, 2–3: 1 ..... *B. salebrosum*
5. Costa percurrent or nearly so ..... *B. populeum*
5. Costa ending near the middle 6
6. Seta rough only above; scales ovate-lanceolate 7
6. Seta rough throughout; scales ovate 8
7. Scales plicate, long and slenderly acuminate ..... *B. campestre*
7. Scales non-plicate, shorter, often secund ..... *B. plumosum*
8. Very short-acuminate, dendroid, basal cells hyaline, well defined, forming auricles ..... *B. rivulare*
8. Gradually slender-acuminate, non-dendroid, basal cells greenish, not distinctly auricled ..... *B. rutabulum*

1. *B. salebrôsum* (Hoffm.) Br. & Sch. (*Hypnum salebrosum* Hoffm.; *Hypnum plumosum* Huds.) Yellowish-green mats, irregularly branched; scale ovate-lanceolate, abruptly acuminate, concave, decurrent; seta about ¾ in. long, castaneous, twisted, sporangium arcuate, horizontal, inner peristome about the same height as the teeth, cilia nodose, basal membrane one-third the height of the teeth. Autumn. Cosmopolitan in shady places. "Common," H. C. Beardsley's catalog. No specimen.

2. *B. campéstre* (Bruch.) Br. & Sch. (*Hypnum campestre* Bruch.) Similar to *B. salebrosem* except for the seta's being rough above. Winter. Earth, rocks and rotting logs. Not reported.

3. *B. oxycl̀adon* (Brid.) Jaeg. (*B. laetum* Br. & Sch.; *Hypnum oxycladon* Brid.) Yellowish-green, broadly and laxly cespitose; scales lanceolate, gradually acuminate, deeply plicate, margins finely serrulate, decurrent; seta castaneous, ¾–1 in. long, sporangium brown. Autumn. Rocks, earth and tree bases in woods. Clark, Perry.

4. *B. acùtum* (Mitt.) Sull. (*Hypnum acutum* Mitt.) Glossy, yellowish-green lax, branchlets short; scales erect-spreading, not striate or plicate, only slightly concave, finely serrulate to entire; auricled; seta flexuous, sporangium ovoid-oblong, inclined to horizontal, somewhat arcuate. Late fall. Earth and rotting logs in swampy woods. Champaign, Lake.

5. *B. rutâbulum* (L.) Br. & Sch. (*Hypnum rutabulum* L.) Robust, glossy, yellowish-green, creeping, branches somewhat attenuate; scales ovate, acuminate, slightly decurrent, faintly serrulate, scarcely concave; seta castaneous, about 1 in. in length, sporangium castaneous, oblong-ovoid, arcuate, almost horizontal, teeth slender, basal membrane one-half the height of the segments Early winter. In moist woods on earth, stones, logs and tree bases. Champaign, Clark, Erie.

6. *B. rivulàre* (Bruch.) Br. & Sch. (*Hypnum rivulare* Bruch.; *B. flavescens* Lindb.) Robust, bright to yellowish-green, variable, branches somewhat erect and dendroid; scales distant, ovate, erect-spreading, concave, decurrent, acute to acuminate, plicate, branch

scales more ovate-lanceolate; seta ¾–1 in. in length, castaneous, sporangium arcuate, strongly inclined to horizontal, lid acuminate. Early winter. On rocks in water or the margin of streams where they are often submerged. Lake, Licking.

7. *B. populeum* (Hedw.) Br. & Sch. (*Hypnum populeum* Hedw.) Slender, densely cespitose, dark to yellowish-green, creeping with branches ascending and curved; scales erect to erect-spreading when moist, nonstriate, imbricated when dry, ovate-lanceolate, slenderly acuminate, slightly decurrent, costa strong nearly to the apex, margin serrate to almost entire; seta castaneous, about ½ in. long, sporangium curved, ovoid-oblong. On shady soil, rocks, roots and bases of trees in woods. Not reported.

8. *B. acuminàtum* (Hedw.) Kindb. (*Leskea acuminata* Hedw.; *Hypnum acuminatum* Beauv.) Densely cespitose, glossy, dark to yellowish-green, prostrate creeping, branches short, plumose to somewhat julaceous; scales erect-spreading, narrowed at the base, somewhat decurrent, slightly plicate, costa to the middle, alar cells quadrate; seta castaneous, about ½ in. long, sporangium cylindrical, erect, slightly arcuate, teeth narrow, hyaline above, cilia rudimentary or none. Autumn. Decaying wood, rocks, roots and bases of trees in the woods. Clark, Franklin, Perry.

9. *B. plumòsum* (Sw.) Br. & Sch. (*Hypnum plumosum* Sw.; *Hypnum flagellare* Hedw.; *B. flagellare* Jenn.) Loosely cespitose, brown beneath, creeping with ascending to erect branches; scales erect or imbricated, lance-ovate, abruptly acuminate, costa ending near the middle, decurrent, serrate to entire, slightly decurrent; seta castaneous, stout; sporangium oblong-ovoid, dark, horizontal to almost erect, peristome teeth confluent at the base, hyaline at the tips. Autumn. Wet rocks in streams. Not reported.

4. CIRRIPHYLLUM Grout.

Widely cespitose, glossy, light or yellowish green, robust; branches julaceous, often with flagellæ; scales uniform, very concave, ovate to oblong-ovate, base decurrent, margin plane, costa simple to the middle of the scale; sporangium cernuous to horizontal, ovoid to oblong-ovoid, lid long-rostrate, conic.

1. Robust; acumination short; seta smooth..... *C. boscii*
1. More slender; acumination one-half as long as the rest of the scale; seta rough..... *C. piliferum*

1. *C. pilíferum* (Schreb.) Grout. (*Hypnum piliferum* Schreb.; *Eurynchium piliferum* Br. & Sch.) Yellowish-green, prostrate, creeping to 5 in. long, rather distinctly pinnate; scales oblong-ovate, abruptly piliferous acuminate, costa wide, alar cells enlarged; seta ¾–1 in., sporangium arcuate, strongly so when dry, segments equalling the teeth in length, cilia non-appendiculate. Autumn; rarely fruiting. Wet soil and bases of trees in woods and swamps. Champaign.

2. *C. bôscii* (Schweg.) Grout. (*H. boscii* Schwaeg.; *Eurynchium boscii* Jaeg.) Loose deep mats, yellowish-green, dark below, prostrate with erect simple branches to 5 in. long; scales oblong-ovate, abruptly

acuminate, accumination twisted, costa simple, or short and double, alar cells and indistinct group, seta 1 in. or more long, golden-brown, sporangium slightly arcuate, inclined. Autumn. Soil or rocks in moist open woods or fields. Champaign, Clark, Fairfield, Lawrence, Muskingum.

5. EURYNCHIUM Br. & Sch.

Cespitose, yellowish-green or green; scales rather dense, usually plicate, costa to the middle or farther, somewhat decurrent, margin plane, serrate; lid with a long needle-like beak.

1. Scales spreading; branches elongated.....*E. pulchellum*
1. Scales appressed-imbricate; branches julaceous, short.....*E. diversifolium*

1. *E. pulchéllum* (Hedw.) Jenn. (*Hypnum pulchellum* Hedw.; *Hypnum strigosum* Hoff.; *Eurynchium strigosum* Br. & Sch.) Loosely cespitose, stoloniferous branches ascending; gradually attenuate, bright yellowish-green; scales ovate-lanceolate, concave, slightly plicate, costa four-fifths length and ending in a spine on the back; seta smooth, golden-brown, sporangium oblong-ovate, somewhat arcuate, inclined to horizontal; teeth confluent at the base, hyaline at the top. Autumn. Soil, logs, and roots of trees in moist open woods. Lake, Clark.

2. *E. diversifòlium* Br. & Sch. (*Hypnum diversifolium* Schimp.) Denser, yellowish-green, branches not erect; scales dense, ovate, those of the branches obtuse. Fairfield.

6. BRYNHIA Kaurin.

Loosely cespitose, dark green to yellowish or brownish; procumbent or stoloniferous, branches irregularly pinnate; scales loosely imbricated, concave, plicate, decurrent, serrate, costa single, ending near the middle of the scale; seta rough; sporangium cernuous, inclined to horizontal, gibbous dorsally, teeth confluent at the base, apically papillose, calyptra short and thick-rostrate.

1. Branch scales acute to short-acuminate, apex twisted.....*B. novae-angliae*
1. Branch scales long-acuminate; apex not twisted.....*B. graminicolor*

1. *B. nòvæ-angliæ* (Sull. & Lesq.) Grout. (*Hypnum novæ-angliæ* Sull. & Lesq.; *Brachythecium novæ-angliæ* Jaeg. & Sauer.) Bright green above, brownish-green below, branches ascending, distinctly julaceous; scales loosely imbricated when dry, erect-spreading when moist, ovate-lanceolate, maginus plane, ovate to ovate-lanceolate, dorsally papillose by projecting cell-angles, costa to the middle; perichactial scales long-acuminate, ecostate, seta and sporangium dark reddish-brown; sporangium oblong, slightly arcuate. Winter. Soil and rocks in wet, shady places. Lake.

2. *B. graminícolor* (Brid.) Grout. (*Hypnum sullivantii* Spruce.) Loosely to densely cespitose, yellowish-green below, light green, branches erect, short; branch scales ovate-lanceolate, long-acuminate, reflexed below, sharply serrulate, perichaetial scales longer, faintly costate; seta glossy, sporangium reddish-brown, arcuate, inclined to horizontal, somewhat gibbous below, calyptra long-rostrate, curved upward. Winter. Moist shady soil and wet rocks. Clark, Fairfield.

7. OXYRYNCHIUM (Br. & Sch.) Warnst.

Loosely to densely cespitose, creeping, branches irregularly pinnate or fascicled, often complanate, scales non-plicate, only slightly concave, erect-spreading on branches, ovate, plane, serrulate, costa to the middle or beyond, often ending in a dorsal spine; seta rough, sporangium cernuous, inclined to horizontal, dorsally gibbous.

1. Aquatic, seta smooth.....*O. riparioides*
1. Terrestrial, seta rough.....*O. hians*

1. *O. riparioìdes* (Hedw.) Jenn. (*Hypnum riparioides* Hedw.; *Hypnum rusciforme* Neck.; *Eurynchium rusciforme* Milde.; *Rhynchostegium rusciforme* Br. & Sch.) Robust, loosely cespitose, dark, blackish below; primary stems creeping branches erect or ascending; scales ascending or erect-spreading, ovate to oblong, costa to beyond the middle of the scale, perichaetial scales ecostate, abruptly acuminate; seta castaneous, sporangium ovate to ovoid-oblong, inclined to horizontal, constricted below the mouth, lid obliquely rostrate. Early autumn. On dripping rocks or on stones in streams. "Ohio," by Lesquereux. No specimen in the herbarium.

2. *O. hìans* (Hedw.) Jenn. (*Hypnum hians* Hedw.; *Eurynchium hians* Jaeg. & Sauer.; *Hypnum praelongum* Muell.; *Ptergynandrum apiculatum* Brid.) Loosely depressed-cespitose, light to yellowish-green, glossy; scales rather distant, erect-spreading, ovate, non-decurrent, blunt-acute to short-acuminate, often twisted, serrate, rough by thickened angles of the cells, costa ½–⅘ length of the scale, ending in a dorsal spine; seta castaneous, sporangium arcuate, inclined to horizontal, oblong-cylindrical. Autumn. Champaign, Perry.

8. RHYNCHOSTÈGIUM Br. & Sch.

Cespitose, soft; creeping, irregularly pinnate scales dense, non-plicate, narrowed at the base; seta smooth.

1. *R. serrulàtum* (Hedw.) Jaeg. (*Hypnum serrulatum* Hedw.; *Eurynchium serrulatum* Lindb.) Loosely cespitose, bright green, lustrous when dry complanate; scales concave, ovate-lanceolate, costa to the middle, serrulate in the outer portion, apex often twisted, margin plane; seta ¾–1¼ in. long, glossy, sporangium castaneous, arcuate, oblong, constricted below the mouth when dry. Autumn. Soil, logs and roots of trees in moist shade. Clark, Lake.

12. *HYPNACEÆ.*

Various, cespitose, irregularly pinnate, often quite regularly pinnate; scales plurisrate, unistratose, erect-spreading or squarrose to imbricated, often secund or circinate, costa various, basal cells usually differentiated and mostly hyaline; seta elongated, sporangium usually arcuate, inclined to horizontal, peristome double, teeth usually confluent at the base, basal membrane of inner peristome high, segments keeled, calyptra obtuse to acute or short-rostrate.

1. Costa single to middle of scale or beyond..... 2
1. Costa double or none..... 6

2. Costa strong, percurrent or excurrent 3
2. Costa not reaching the apex 5
3. Paraphyllia numerous ..... *Hygroamblystegium*
3. Paraphyllia few or none 4
4. Scales blunt and rounded at the apex, spreading or imbricated .... *Calliergon*
4. Scales acute to acuminate, secund ..... *Drepanocladus*
5. Scales erect-spreading ..... *Amblystegium*
5. Scales squarrose recurved ..... *Campylium*
6. Stem and branch scales dissimilar, scales symmetric and at right angles to the stem 7
6. Stem and branch scales similar, often inserted obliquely on the stem and unsymmetric 12
7. Paraphyllia numerous, annual growth clearly defined ..... *Hylocomnium*
7. Paraphyllia few or none 8
8. Stem scales somewhat squarrose-spreading to secund, acuminate 11
8. Stem scales imbricated, with tips somewhat spreading or secund 9
9. Rugose; scales narrowly lanceolate, acuminate, base broad; serrate at the apex ..... *Rhytidium*
9. Scales broadly ovate or rounded, apex obtuse, faintly crenulate at the apex 10
10. Stems green; in swamps ..... *Acrocladium*
10. Stems red; in dryer places ..... *Hypnum*
11. Irregularly and distantly pinnate; scales squarrose ..... *Rhytidiadelphus*
11. Closely pinnate; scales circinate-secund ..... *Ctenidium*
12. Scales complanate; branches irregular 13
12. Scales not complanate; branches more regularly pinnate, often plumose 14
13. Scales decurrent, alar cells differentiated ..... *Plagiothecium*
13. Scales not or little decurrent, alar cells little or not at all differentiated, *Isopterygium*
14. Scales falcate, circinate, or secund 15
14. Scales mostly spreading 16
15. Very irregularly pinnate; scales plicate; paraphyllia numerous ..... *Ptilium*
15. Irregularly pinnate; scales scarcely or not at all plicate; paraphyllia few or none ..... *Stereodon*
16. Scales strongly falcate-secund, obtuse or apiculate, alar cells distinctly differentiated; aquatic ..... *Scorpidium*
16. Not secund; scales erect-spreading; not aquatic 17
17. Paraphyllia numerous; medium-sized mosses ..... *Heterophyllon*
17. Paraphyllia lacking; small plants 18
18. Dull; scales lanceolate to linear-lanceolate; cells rhomboidal to elongate-hexagonal ..... *Amblystegiella*
18. Shining; scales oval to oblong-lanceolate; cells narrow ..... *Homomallium*

1. ISOPTERYGIUM Mitt.

Slender, cespitose, light or yellowish-green, glossy, irregularly-pinnately branched mostly; scales smooth, base narrow, margin plane, costa very short or none; seta smooth, sporangium actimorphic or weakly gibbous, rarely arcuate, bases of peristome teeth confluent, yellowish, apically hyaline; operculum conic, sometimes rostrate.

1. Scales entire or obscurely serrulate above 2
1. Scales distinctly serrulate at least in the outer half 3
2. Not complanate; two rows of cells at the base shorter and wider .. *I. pulchellum*
2. Complanate, basal cells hardly different ..... *I. mullerianum*
3. Scales shortly bi-costate ..... *I. geophyllum*
3. Scales ecostate or obscurely costate 4
4. Scales serrulate to the base ..... *I. deplanatum*
4. Scales serrulate only in the outer half ..... *I. turfaceum*

1. *I. mullerianum* (Schimp.) Lindb. (*Plagiothecium mullerianum* Schimp.; *Hypnum mullerianum* Hook. f.) Light green, yellowish,

laxly cespitose, branches often stoloniferous or flagelliform; scales ovate-lanceolate, concave, costa very faint, abruptly apiculate, pointing upward; seta castaneous, hypophysis elongated, sporangium erect to inclined, small, rare. Autumn. Rock crevices or soil in ravines. "Ohio," by Lesquereux. No specimen in the herbarium.

2. *I. deplanàtum* (Sull.) Mitt. (*Hypnum deplanatum* Sull.; *Rhynchostegium deplanatum* Schimp.) Bright green, glossy, flattened; scales dense, concave, ovate-lanceolate, thin; sporangium oblong-ovate, arcuate, cernuous, plicate when dry. Autumn, fruit rarely found. Clark.

3. *I. pulchéllum* (Dicks.) Jaeg. (*Hypnum pulchellum* Dicks.; *Plagiothecium pulchellum* Br. & Sch.) Lustrous green, densely cespitose; stems prostrate, branches erect, crowded; scales crowded, sometimes secund, ovate-lanceolate, long, slender acuminate, ecostate, narrowed at the base; sporangium sub-erect to inclined. Summer. Decayed wood, rocks and roots of trees. Champaign.

4. *I. turfàceum* Lindb. (*Hypnum turfaceum* Lindb.; *Plagiothecium turfaceum* Lindb.; *Stereodon turfaceum* Mitt.) Loosely cespitose, light to yellowish-green, prostrate with short branches; scales complanate, ovate-lanceolate, long-acuminate, basal cells wider and shorter; seta castaneous, sporangium oblong, oblique rostrate, slightly arcuate, plicate when empty, annulus large and double. Summer. Lake.

5. *I. geóphilum* (Aust.) Jaeg. (*Rhynchostegium geophilum* Aust.; *Phlagiothecium geophilum* Grout; *Hypnum depressum* Sull. & Lesq.) Loosely cespitose dark, glossy green, prostrate, irregularly branched; scales flat, rather distant, widely spreading, narrowed and rounded at the base, oblong-lanceolate, serrate in the outer half, apex rather blunt, a few basal cells sub-rectangular and hyaline; sporangium ovoid, inclined gibbous, operculum obliquely rostrate. Rare. Wet earth or stones near water in lowlands. Clark.

2. PLAGIOTHÈCIUM Br. & Sch.

Softly cespitose, larger than the preceding genus, bright to yellowish-green, lustrous, creeping to erect or ascending in thick mats, stoloniferous, branches often flagelliform; scales non-plicate, decurrent, ovate to lanceolate, acuminate, base narrowed, basal cells lax and hyaline; seta reddish, sporangium erect to cernuous, oblong to cylindrical, peristome yellowish, teeth confluent at the base.

1. Ascending, not distinctly complanate, spreading ..... *P. roseanum*
1. Stems depressed, distinctly complanate 2
2. Costa strong, forked, often to the middle of the scale; sporangium striate when dry ..... *P. sylvaticum*
2. Costa thin and short; sporangium usually smooth when dry .... *P. denticulatum*

1. *P. sylváticum* (Huds.) Br. & Sch. (*Hypnum sylvaticum* Huds.; *H. denticulatum* C. Muell.) Softly cespitose, duller, olive or yellowish-green, prostrate, stoloniferous; scales concave, oval-lanceolate, decurrent, narrowed at the base, abruptly acute, plane, shrinking when dry so as not to overlap, perichaetial scales long-acuminate, non-costate; seta castaneous, slender, ¾–1½ in. long or more, sporangium yellowish,

arcuate, inclined, hypophysis elongated, striate, peristome orange below, pale above, lid conic, rostrate. Summer. Soil, rocks and wood in the woods. Fairfield, Franklin, Lake.

2. *P. denticulàtum* (L.) Br. & Sch. (*Hypnum denticulatum* L.) Flatly cespitose, pale green, lustrous, branches ascending; scales rather dense, sub-concave, little shrunken when dry, ovate-oblong, acute to short-acuminate, entire below, slightly denticulate near the apex, margin plane, widest at the base; seta 1–1¼ in., copper-colored, sporangium arcuate, cylindric, suberect to horizontal, hypophysis long, lid conic, peristome hyaline above. Summer. Logs, stones and humus in the woods. Ashtabula, Fairfield, Franklin, Hancock.

3. *P. roseànum* Br. & Sch. (*P. sullivantiæ* Schimp.; *Hypnum roseanum* Hampe.) Densely cespitose, yellowish-green, shining; sparingly branched; scales dense, ovate-oblong, short-acuminate, concave, serrulate near the apex, costa distinct; sporangium oblong-cylindrical, erect to inclined, lid oblique-rostrate, short. Summer. Stones and soil in swampy woods. Clark, Fairfield, Lake.

3. AMBLYSTÈGIUM Br. & Sch.

Cespitose, irregularly branched, branches more or less erect; scales erect-spreading to squarrose, acuminate, concave, non-plicate, costa thin to the middle or beyond; seta long, reddish or castaneous; sporangium arcuate, yellow or orange, constricted below the mouth when dry, lid conic.

1. Costa nearly percurrent to excurrent..... **2**
1. Costa ending well below the apex, usually near the middle..... **4**
2. Sharply and finely denticulate; median cells 6–10: 1; very slender, densely tufted.....*A. compactum*
2. Larger; obscurely denticulate or entire; median cells 3–6: 1..... **3**
3. Scales ovate-acuminate, acute, slender acuminate.....*A. varium*
3. Scales ovate-cordate, abruptly and bluntly acuminate.....*A. orthocladon*
4. Slender, creeping; scales erect-spreading; median cells 2–6: 1..... **5**
4. More robust, ascending; scales wide to squarrose-spreading; median cells 5–10 (15): 1.....*A. riparium*
5. Median cells 2–4: 1.....*A serpens*
5. Median cells 4–6 (8): 1.....*A radicle*

1. *A. sêrpens* (L.) Br. & Sch. (*Hypnum serpens* L.) Very small and slender in thin compressed, dull mats, densely interwoven, prostrate, radiculose, irregularly branched; scales ovate-lanceolate, long-acuminate; serrulate to entire, decurrent, narrow at the base, plane, costa often faint; seta slender, ¾–1 in. long, sporangium strongly arcuate, lid apiculate, teeth pale. Early summer. Bases of trees, roots, long, soil, rocks, etc., in moist woods. Clark, Lake, Seneca.

2. *A. vàrium* (Hedw.) Lindb. (*Leskea varia* Hedw.; *Stereodon varius* Mitt.; *Hypnum debile* Brid.) Mats of varying density, dark green below, lighter above, prostrate, branches erect or ascending, irregular; scales rather dense; ovate-acuminate, entire or slightly denticulate, plane erect-spreading, decurrent, narrowed at the base, costa strong and well above the middle, basal cells larger and sometimes yellowish; seta ¾–1¼ in., castaneous, sporangium castaneous, strongly

arcuate. Spring. Stones, wood, bases of trees, etc., in moist places. Clark, Fairfield, Fulton, Lawrence, Logan, Montgomery.

3. *A. radicàle* (Beauv.) Mitt. (*A. serpens* var. *radicale* Aust.; *Hypnum radicale* Beauv.; *Hypnum bergense* Aust.; *Campylium radicale* Grout; *A. hygrophilum* (Jur.) Schimp.) Loose thin mats, pale-green, slender and little branched; scales distant, spreading, lanceolate to ovate-cordate, decurrent, slenderly acuminate, alar cells often enlarged and hyaline, costa orange; seta an inch or more in length, castaneous, sporangium yellowish, peristome teeth hyaline margined, sporangium castaneous. Spring. Rotten logs, roots, soil, in wet shady places. Lake.

4. *A. orthocladon* (Beauv.) Jaeg. (*A. varium* var. *orthocladon* Husnot.; *Hypnum orthocladon* Beauv.) Dark to olive-green, compact, irregularly branched, branches erect; scales ovate-cordate, wide-spreading, base narrow, margins plane, serrulate, costa to the apex; seta castaneous, sporangium castaneous, arcuate, cernuous, constricted below the mouth when dry. Spring. Moist, shady stones, and rotten wood at the bases of trees. Clark, Fairfield, Franklin, Fulton, Lake, Logan, Montgomery.

5. *A. ripàrium* (L.) Br. & Sch. (*H. riparium* L.; *H. laxifolium* Brid.; *Stereodon riparium* Mitt.) Variable in loosely cespitose flat, soft tufts or floating in running water, creeping, sub-pinnate, ¾–1 in. or more in length, 2–3 in. in floating forms, depressed; scales widely spreading, sometimes secund at tips, ovate-lanceolate to oblong-lanceolate, gradually and finely acuminate, flat, somewhat decurrent, rounded at the base, costa strong; sporangium oblong-cylindric, dark, lid apiculate. Spring. Clark, Champaign, Franklin, Lake.

6. *A. compáctum* (C. Muell.) Aust. (*Hypnum compactum* C. Muell.) Small, densely cespitose, light or yellowish-green, branches numerous; scales erect-spreading, lanceolate to ovate-lanceolate, long-acuminate, finely denticulate, seta short, sporangium erect or slightly inclined. Rotten logs or wet bases of trees. Champaign.

4. AMBLYSTEGIÉLLA Loesk.

Slender, filiform, creeping; scales erect-spreading or sometimes slightly secund, lanceolate to lance-subulate, margin plane, entire, costa faint or none; seta castaneous or reddish-yellow, sporangium usually erect and actinomorphic, constricted below the mouth when dry, peristome yellow, teeth confluent and bordered, cilia rarely complete.

1. Plants minute; scales not narrowed at the insertion.....*A. minutissima*
1. Plants larger; scales narrowed at the insertion.....*A conferva*

1. *A. minutíssima* (Sull & Lesq.) Nichols. (*H. minutissimum* Sull. & Lesq.; *Amblystegium minutissimum* Jaeg.) Light green, prostrate, radicles fasciculate, branches erect or spreading; scales triangular, faintly serrate, ecostate; sporangium minute, ovoid, turbinate, when empty, lid conic, apiculate-rostrate. Rocks and stones in ravines. "Ohio," L. & J. Manual.

2. *A. conférva* (Schweg.) Jenn. (*Hypnum confervoides* Brid.; *Amblystegium confervoides* Loesk.; *Hypnum conferva* Schweg.) Dark green, irregularly branched; scales rather distant, almost or quite entire, ovate, acuminate ecostate, somewhat appressed; sporangium arcuate, inclined, reddish-brown. Summer. Green, Clark.

5. HOMOMÁLLIUM (Schimp.) Loeske.

Shining, slender, creeping, pinnately branched with branches erect or ascending; scales erect-spreading, often secund at the tips, concave, non-plicate, ovate to oblong-lanceolate, long-subulate, plane, ecostate, or costa double, short and faint; seta reddish, sporangium inclined to horizontal, strongly arcuate when dry, constricted below the mouth, peristome yellow, teeth confluent basally, operculum short-rostrate.

1. *H. adnàtum* (Hedw.) Broth. (*Hypnum adnatum* Hedw.; *Amblystegiella adnata* Nichols; *Stereodon adnatum* Mitt.) Densely cespitose, light green above, darker below, branches close; scales dense, entire or nearly so, concave, recurved below; seta ½–¾ in. long, hypophysis long, sporangium reddish. Autumn. Clark, Franklin.

6. HYGOAMBLYSTÈGIUM Loeske.

Cespitose, dark green, dull, aquatic, often floating, pinnately branched; scales dense, spreading to secund, concave, non-plicate, ovate to lanceolate, long-acuminate, costa stout; seta castaneous, sporangium arcuate and constricted below the mouth when dry.

1. Scales entire or obscurely serrate, non-decurrent 2
1. Scales distinctly serrate, teeth small; mostly decurrent ..... *H. filicinum*
2. Scales sharply acute or acuminate ..... *H. tenax*
2. Scales obtuse, not acuminate ..... *H. fluviatile*

1. *H. fluviâtile* (Swartz) Loeske. (*Amblystegium fluviatile* Br. & Sch.; *Hypnum fluviatile* Swartz.) Robust, gametophores to 4 in. long, olive or dark green, or blackish, naked below; scales oblong-lanceolate to oblong-ovate, remote, erect-spreading, concave, recurved at base, costa percurrent, yellowish, basal cells often yellowish or orange; seta about ½ in. long, sporangium oblong-cylindrical, sub-erect, yellowish, brown, slightly curved; teeth strongly confluent at the base, hyaline and papillose at the apex, cilia nodose, three. Early summer. Earth and stones near running water in non-calcareous districts. Clark, Fairfield.

2. *H. tenax* (Hedw.) Jenn. (*H. irriguum* Loeske; *Hypnum irriguum* Wils.; *Amblystegium irriguum* Br. & Sch.; *Hypnum tenax* Hedw.) Cespitose, dark green, rigid, irregularly branched, pinnate, with long paraphyllia at the insertion of the branches; scales deltoid-ovate-lanceolate, gradually long-acuminate, somewhat narrowed at the base and slightly decurrent, spreading, somewhat secund at the tips, cost percurrent, basal cells enlarged, yellowish; seta ½ in. long, sporangium brown, oblong, lid apiculate, peristome orange, pellucid. Late spring and early summer. Earth or stones in swampy places in non-calcareous regions. Greene, Wyandot.

3. *H. filicìnum* (L.) Loeske. (*Amblystegium filicinum* DeNot.; *Stereodon filicinus* Mitt.; *Hypnum filicinum* L.; *Cratoneuron filicinum* G. Roth; *Hypnum compressum* Brid.) Variable, tufted, 2–4 in. deep, bright to yellowish-green, brown below, densely tomentose, paraphyllia laciniate, quite regularly pinnate; scales cordate-deltoid, gradually slender-acuminate, erect-spreading, secund at the tips of the gametophores, non-plicate; costa percurrent, alar cells inflated, hyaline or colored, auricled; seta 1–1½ in. long, sporangium sub-cylindric. Spring. On earth or stones in springs or streams in limestone regions. Champaign, Lake.

7. DREPHANOCLÀDUS (C. Muell.) Roth.

Robust, usually glossy, stems procumbent to erect or floating; scales strongly secund, concave, decurrent, acute to long-acuminate, costa thin, usually single, smooth, basal cells hyaline or yellowish, well-defined; seta long, sporangium cylindric, arcuate, constricted below the mouth when dry, lid apiculate.

1. Alar cells not inflated or decurrent, but thicker and broader, scales entire ..... *D. revolvens*
1. Alar cells distinctly enlarged and inflated, often either decurrent or serrate or both 2
2. Scales entire, alar cells greatly enlarged 4
2. Some or all scales plainly dentate 3
3. Scales plicate ..... *D. uncinatus*
3. Scales not plicate ..... *D. fluitans*
4. Acumen flat, scarcely or not at all hooked ..... *D. kneifii*
4. Acumen channeled, tips hooked 5
5. Gradually long-acuminate ..... *D. aduncus*
5. Abruptly short-acuminate ..... *D. aduncus* var. *gracilescens*

1. *D. uncinàtus* (Hedw.) Warnst. (*Hypnum uncinatus* Hedw.; *Amblystegium aduncum* Lindb.; *Hypnum aduncum* L.) Densely cespitose, light to golden-green, irregularly pinnate; scales dense, falcate to circinate, lanceolate, acuminate long, dentate above, costa into the acumen, strongly plicate, basal cells only slightly enlarged and inflated; seta 1 in. or more long, copper colored, sporangium reddish-orange, arcuate. Early summer. Earth, stones, logs and bases of trees in moist shady places. Champaign, Clinton, Fairfield, Franklin, Lake.

2. *D. revôlvens* DeNot. (*Hypnum revolvens* Sw.) More robust, 2–3 in. deep, loosely tufted, yellowish or light green above, dark reddish-purple below; scales linear-lanceolate, long slender-acuminate, costa to above the middle; sporangium erect, cernuous, oblong-ovoid, scarcely constricted below the mouth when dry. In wet soil. Reported from the swamps of northern Ohio by Lesquereux.

3. *D. adûncus* (Hedw.) Warnst. (*Hypnum aduncus* Hedw.; *Amblystegium watsonii* (Sch.) Lindb.) Slender and soft, green or golden green, darker below; scales rather distant, moderately hooked at the tip of branch, wide cordate at base, strongly excavate, forming a complete semicircle between the auricles, costa to about ¾ the length of the scale, lanceolate, often twisted, basal cells abruptly inflated; the scale, seta 1 in. or more long, sporangium oblong, arcuate, inclined. Wet soil and stones or floating in deep pools. Champaign, Lake.

4. *D. aduncus* var. *gracilescens* Br. & Sch. (*D. subaduncus* Warnst.) Sparingly branched, branches short and erect, yellowish-green; scales ovate to ovate-lanceolate, base less deeply and widely excavate than in the species. Late spring. Swamps and wet places. Fruit rare. Lake.

5. *D. kneifii* (Schimp.) Warnst. (*Hypnum aduncum* var. *kneifii* Schimp.; *Amblystegium kneifii* Br. & Sch.) Branches slender, long and flexuous; little hooked at the tips; scales distant, narrow lanceolate, upper one wider and shorter, alar cells inflated, and extending to the costa. Late spring. Fruit rare. In water in swamps and streams. Not reported.

6. *D. fluitans* (L.) Warnst. (*Amblystegium fluitans* DeNot.; *Hypnum fluitans* L.) Soft tufts, 2–3 in. deep, irregularly pinnate, erect, light or yellowish-green above, brown below; scales secund, narrow or oblong-lanceolate, very long acuminate, non-plicate, costa extending into the acumen or percurrent, denticulate, not deeply excavate; seta 1 in. or more, copper-colored, sporangium arcuate, reddish-orange, annulus none. Summer. In water in swamps and streams. Clark.

8. CALLIÉRGON (Sull.) Lindb.

Robust, erect; scales not falcate or secund obtuse, broadly oblong-ovate to almost orbicular, concave, costa simple and strong or wanting; sporangium arcuate, inclined to horizontal, peristome hypnoid.

1. Scales imbricate when dry; almost simple mosses..... 2
1. Scales erect-spreading or loosely imbricated; branched..... 3
2. Scales almost round, very obtuse; auricles indistinct.....*C. trifarium*
2. Scales oblong, auricles distinct.....*C. stramineum*
3. Sparingly branched, alar cells gradually passing to the ordinary cells, *C. cordifolium*
3. Much branched; alar cells abruptly differentiated from the ordinary cells.....*C. giganteum*

1. *C. cordifòlium* (Hedw.) Lindb. (*Hypnum cordifolium* Hedw.; *Amblystegium cordifolium* DeNot.) Large mosses, 4–6 in. tall, light green, loose tufts, stalks erect, slender; scales distant, widely spreading, ovate-cordate, entire, decurrent; seta to 2 in. long, castaneous, sporangium golden-brown. Summer. Swamps or margins of pools or sluggish streams. Lake.

2. *C. gigânteum* (Schimp.) Lindb. (*Hypnum giganteum* Schimp.; *Amblystegium giganteum* DeNot.) Very robust, 3–6 in. tall, loosely tufted, stalks thick, pinnately branched, bright green, brown below; scales oblong, alar cells hyaline; seta castaneous, 2 in. or more long, sporangium distinctly arcuate, brown. Late spring and early summer. Swamps and bogs. Champaign.

3. *C. stramíneum* (Dicks.) Lindb. (*Hypnum stramineum* Dicks.; *Amblystegium stramineum* DeNot.) Pale green, loose tufts, 2½–3 in. deep, stems erect and slender; scales oblong-ovate to oblong, costa to beyond the middle, alar cells hyaline, forming distinct decurrent auricles, a patch of shorter cells in the apex; sporangium oblong-cylindrical. Summer. In bogs, often among sphagnum. Erie.

4. *C. trifàrium* (Web. & Mohr.) Kindb. (*Hypnum trifarium* Web. & Mohr.; *Amblystegium trifarium* DeNot.) Robust, golden or dirty green above, brown below, tufts loose, prostrate to erect, stiff and brittle when dry; scales loosely imbricated, ovate, wide slightly decurrent, entire, wide near the middle, alar cells enlarged and hyaline; sporangium cernuous, horizontal, reddish. Bogs and pools. Erie.

9. SCORPÍDIUM (Schimp.) Limpr.

Very robust, sparingly branched, branches fastigate; scales strongly secund, imbricate, turgid, broad-ovate, costa indistinct or none.

1. *S. scorpioìdes* (L.) Limpr. (*Hypnum scorpioides* L.; *Amblystegium scorpioides* Lindb.) Soft tufts, brownish-green, above, almost black below, branches erect or ascending, almost simple, 4–6 in. long; scales very concave, imbricated, rugose, non-plicate, ovate-oblong, narrowed at the base, entire, costa very short and double, obtuse or apiculate, a few basal cells wider and hyaline; seta long, sporangium arcuate, not constricted below the mouth when dry. Late summer. Bogs and marshes in the water. Champaign. "Cranberry marshes of northern Ohio," Lesq.

10. CAMPYLIUM (Sull.) Mitt. (*Chrysohypnum* [Hampe.] G. Roth.)

Soft thin mats; scales ovate-acuminate, acute, widely spreading, squarrose, or secund not falcate; sporangium arcuate, usually contracted below the mouth when dry, lid conic-convex, peristome hypnoid.

1. Costa single, distinct, half the length of the scale..... *C. chrysohypnum*
1. Costa short and double or wanting..... 2
2. Stems prostrate; scales serrulate..... *C. hispidulum*
2. Stems erect or ascending; scales entire..... *C. stellatum*

1. *C. hispídulum* (Brid.) Mitt. (*Hypnum hispidulum* Brid.) Thin tufts, small, slender, creeping, bright green, irregularly branched; scales widely spreading to squarrose, triangular-cordate, abruptly acuminate, decurrent; seta copper-colored, 1 in. long, sporangium light, much curved, mouth wide. Early summer. Wood, humus and roots of trees in moist woods. Champaign, Clark, Fairfield, Franklin, Fulton, Geauga, Lake, Lawrence, Richland.

2. *C. chrysophyllum* (Brid.) Bryhn. (*Hypnum chrysophyllum* Brid.; *Hypnum polymorphum* Br. & Sch.) Thin, delicate, loose mats, bright or yellowish-green, creeping, irregularly branched; scales squarrose-spreading, base narrowed, somewhat clasping, occasionally secund, ovate-cordate, abruptly acuminate; seta copper-colored, sporangium much curved, peristome light. Early summer. Earth, wood and stones in moist places. Champaign, Clark, Fairfield, Greene, Montgomery, Pickaway, Seneca, Lake.

3. *C. stellàtum* (Schreb.) Bryhn. (*Hypnum stellatum* Schreb.; *Amblystegium stellatum* Lindb.) Robust, 2–4 in. tall, variable in appearance, soft tufts, bright green, brown below; scales squarrose or recurved, bistriate at base, alar cells inflated, hyaline or colored, base ovate or cordate, rather abruptly acuminate; seta brown, sporangium

dark reddish-brown, cernuous, constricted below the mouth when dry, teeth orange at the base, lighter above. Summer. Swamps, in water or on wet soil. Champaign.

11. CTENÍDIUM (Schimp.) Mitt.

Loosely cespitose, densely bi-pinnately branched, plumose; scales long-acuminate, circinate, secund, costa short and double; sporangium sub-horizontal, curved, thick-ovate, lid conical-apiculate.

1. *C. mollúscum* (Hedw.) Mitt. (*Hypnum molluscum* Hedw.) Wide soft mats, yellowish-green, stems to 3 in. long, prostrate, or ascending; scales cordate-triangular, auricled round, quadrate cells not much enlarged, pellucid crisped when dry, plane, serrate, decurrent, more or less rough by the projecting angles of the cells, paraphyllia few. Summer. Earth or stones in limestone regions. Champaign, Lake.

12. PTÍLIUM (Sull.) DeNot.

Robust in deep loose tufts, frondiform, stems rigid, closely and regularly pinnately branched; scales sulcate, seta long and slender, falcate, secund; sporangium arcuate to horizontal, oblong-cylindric.

1. *P. crísta-castrênsis* (L.) DeNot. (*Hypnum crista-castrensis* L.) Bright, yellowish-green, darker below, 2–5 in. deep, strikingly plumose, branches horizontally divergent, about equal in length except at the tips; paraphyllia numerous; scales plicate, crowded, serrate in the outer part, alar cells enlarged, hyaline, decurrent, costa short and double or wanting; seta reddish-brown, sporangium lighter, 1–1½ in. long, lid large, teeth orange at the base. Summer. Earth or rotten logs in wet woods. "Northern Ohio," H. C. Beardsley.

13. HYLOCÒMNIUM Br. & Sch.

Robust, loosely cespitose, paraphyllia abundant in our species, annual growth well marked, plumose, tripinnate, or bipinnate; scales occasionally papillose on the back by projecting angles, basal cells often colored; sporangium curved, inclined to horizontal, peristome hypnoid.

1. Regularly bi- or tri-pinnate; stem scales gradually acuminate, not auricled, *H. splendens*
1. Irregularly pinnate; stem scales abruptly acuminate; auricled..*H. brevirostre*

1. *H. brevirôstre* (Ehrh.) Br. & Sch. (*Hypnum brevirostre* Ehrh.) Tufts large, 3–5 in. deep, coarse, rather rigid, paraphyllia small; stem scales spreading, squarrose, or sub-secund, obcordate-ovate to cordate-triangular, faintly bi-costate, serrulate above, auricles rounded; sporangium arcuate, turgid-oblong, ovate, lid acuminate, sub-rostrate, or long conical, teeth orange. Spring. Rocks and bases of trees in wet ravines. Lake.

2. *H. splêndens* (Hedw.) Br. & Sch. (*Hypnum proliferum* L.; *Hylocomnium proliferum* Lindb.; *Hypnum splendens* Hedw.) Loose rigid tufts pale green above, darker below, paraphyllia branched, annual growth arcuate; stem scales wide-ovate to oblong-ovate, rather

abruptly acuminate, acumen long, plicate, concave, basal cells orange, costa obscure, double; sporangium turgid-ovate, lid rostrate. Spring. Log and stones in moist woods. Cuyahoga.

14. HYPNUM (Dill.) L.

Robust, prostrate to ascending, irregularly pinnate; scales loosely imbricated, costa double and short or none, obtuse, deeply concave; sporangium oblong, arcuate, lid conic-convex.

1. *H. schrêberi* Wild. (*Hylocomnium schreberi* DeNot.; *Hypnum parietum* L.; *Hylocomnium parietum* Lindb.) Densely cespitose, cushions 2–5 in. deep, pale grayish-green or olive green, glossy, older stems bright red; scales ovate to oblong, dense, obtuse, incurved at the apex, plicate, entire or slightly crenulate in outer portion, alar cells enlarged, hyaline or colored; sporangium inclined, reddish, annulus none, seta purple. Fruit rare. Autumn. Dry open woods, banks, etc. Champaign, Lake.

15. RHYTÍDIUM (Sull.) Lindb.

Robust, non-radiculose, irregularly pinnate, paraphyllia lacking; scales plicate, costa simple to beyond the middle, calyptra large, lid rostrate, annulus broad.

1. *R. rugôsum* (Ehrh.) Lindb. (*Hypnum rugosum* Ehrh.; *Hylocomnium rugosum* DeNot.) Large, 2–4 in. deep, dense mats, bright yellowish-green, glossy, tumid; scales strongly secund, papillose on back, transversely undulate-rugose, revolute, denticulate, alar cells numerous, quadrate; sporangium oblong-cylindric, deeply arcuate, constricted below the mouth when dry. Fruit rare. Summer. Dry banks among the grass and on ledges. Greene, Lake.

16. RHYTIDIADÉLPHUS (Lindb.) Warnst.

Robust, irregularly and distantly bi- or tri-pinnate; scales squarrose or spreading-secund, paraphyllia lacking; sporangium turgid, ovate.

1. *T. triquêtris* (L.) Warnst. (*Hypnum triquetrum* L.; *Hylocomnium triquetrum* Br. & Sch.) Very robust, wide tufts, 4–6 in. deep, yellowish to light green, stems stiff, reddish, erect or ascending, branches unequal, not complanate; scales widely spreading deltoid to broadly ovate, stiff, rarely secund, gradually tapering, acute, plicate, denticulate, papillose on the back; seta 1–1½ in. long, sporangium oblong, lid conic-acute, teeth orange with a yellow border. Spring. Soil in swampy or dry woods. Champaign, Fairfield, Lake.

17. ACROCLÀDIUM Mitt.

Robust mosses, loosely tufted, irregularly pinnate; scales spreading, costa double and very short or ecostate, entire, obtuse; sporangium oblong, arcuate.

1. *A. cuspidàtum* (L.) Lindb. (*Hypnum cuspidatum* L.; *Stereodon cuspitatus* Brid.) Bright or yellowish-green, glossy, branches cuspidate at the tips; lower scales erect-spreading, oblong-elliptical, rounded at the

apex, alar cells suddenly enlarged, hyaline or colored, auricles large and decurrent; seta 1½–2½ in. long; sporangium strongly arcuate, golden-brown, teeth hyaline-bordered. Summer. Wet meadows, swamps and bogs. Summit.

18. STÉREODON (Brid.) Mitt.

Pinnately branched, more or less regularly; scales falcate-secund, smooth, acuminate, costa double or wanting; sporangium usually curved, sub-erect to inclined, lid short-rostrate.

1. Alar cells inflated, hyaline or colored 2
1. Alar cells quadrate, not enlarged 7
2. Quite distinctly pinnate 3
2. Not distinctly pinnate 6
3. Sporangium sub-erect; stems reddish 4
3. Sporangium curved or inclined; stems not reddish 5
4. Robust, closely pinnate, more or less complanate ..... *S. impones*
4. Slender, branches few, not complanate ..... *S. tenuirostris*
5. Small yellowish; sporangium non-plicate ..... *S. fertile*
5. Larger, dark green; sporangium plicate when dry ..... *S. curvifolium*
6. Scales entire; alar cells rather few ..... *S. pratense*
6. Scales sharply serrate above; alar cells conspicuous ..... *S. recurvans*
7. Scales entire; not regularly pinnate ..... *S. cupressiformis*
7. Scales serrulate, at least above; regularly pinnate ..... *S. reptilis*

1. *S. rĕptilis* (Rich.) Mitt. (*Hypnum reptilis* Rich.) Small, dark or yellowish-green, loosely cespitose; scales dense, lanceolate-acuminate serrate above, usually serrulate below, lower margins revolute, alar cells quadrate, somewhat colored, costa yellowish when present; seta about ½ in. long, sporangium yellowish, curved near the mouth and narrowed, lid oblique-rostrate. Summer. Bases of trees, logs, etc., in woods. Clark.

2. *S. fĕrtilis* (Sendt.) Lindb. (*Hypnum fertile* Sendt.) Lustrous, densely cespitose, prostrate or ascending to 3 in. long, branches sparse, short; scales oblong-lanceolate, long and narrowly acuminate, concave, plane, entire below, serrulate above, narrowed at the base, a few alar cells inflated at the margin; seta ½–¾ in., castaneous, sporangium inclined to horizontal, oblong, arcuate, castaneous, rim darker, somewhat constricted below the mouth when dry, lid conic, acute. Wood decaying in moist places. Champaign.

3. *S. impŏnens* (Hedw.) Lindb. (*Hypnum imponens* Hedw.) Wide, densely interwoven, yellowish mats, stems prostrate, closely pinnate, forming flat fronds, paraphyllia numerous; scales ovate at base, gradually long-acuminate, strongly falcate-secund, somewhat complanate, margin usually recurved below, alar cells quadrate with a few inflated and orange pellucid in angles, auricled; seta slender, castaneous, 1–1½ in. long, sporangium reddish-brown, slightly curved, nearly erect, lid long-rostrate, acuminate. Autumn or early winter. Stones, soil or wood in moist woods. Clark, Fairfield, Franklin, Greene, Lake, Lawrence, Licking.

4. *S. cupressifŏrmis* (L.) Lindb. (*Hypnum cupressiformis* L.) Wide, densely-interwoven mats, yellowish to brownish-green, variable in size, paraphyllia less numerous than in the preceding species, more

irregularly pinnate, prostrate; scales dense, imbricated, concave, oblong to ovate, abruptly acuminate, entire below, serrulate above, subulate, alar cells few, clear, usually hyaline; sporangium curved, oblong-constricted below the mouth when dry, lid acuminate. Late autumn or early winter. Earth, stones, roots of trees in moist woods. Lake, Seneca.

5. *S. cupressiformis* var. *ericetòrum* (Br. & Sch.) (*Hypnum cupressiforme* var. *ericetorum* Br. & Sch.) Soft, pale green, lustrous; scales less dense than in the species, narrow and more widely spreading, circinate-falcate; sporangium shorter, lid short-subulate. Perry.

6. *S. cupressiformis* var. *filifórmis* (Brid.) Jenn. (*Hypnum cupressiformis* var. *filiformis* Brid.) Slender, distantly pinnate, branches long, slender and parallel, mats thin; scales in two rows, imbricated. On soil rocks and rotten wood in moist woods. Franklin.

7. *S. curvifòlius* (Hedw.) Brid. (*Hypnum curvifolium* Hedw.) Wide, flat, yellowish-green mats, branches short and unequal, closely pinnate, prostrate; scales in two rows, falcate-secund, appearing plaited from above, entire or serrulate in the outer part, concave, oblong-ovate to long-triangular-ovate, slightly decurrent with enlarged and hyaline cells, alar cells sub-quadrate; seta 1–1½ in. long, castaneous, sporangium light castaneous, constricted below the mouth when dry, arcuate, cernuous, teeth yellow-pellucid, lid conic-apiculate. Spring. Decaying logs, and rocks in cool moist woods. Champaign, Clark, Fairfield, Lake, Williams.

8. *S. pratênse* (Koch.) Warnst. (*Hypnum pratense* Koch.; *Isopterygium pratense* Lindb.) Flatly cespitose, complanately branched, bright green; scales slightly concave or plane, only slightly secund, alar cells colored, few; sporangium non-plicate, ovate to oblong, cernuous, arcuate, seta twisted in two directions, fruit rare. Spring. Wet or swampy soil. Franklin.

9. *S. recûrvans* (Rich.) Broth. (*Hypnum recurvans* Schwaeg.; *Sematophyllum recurvans* E. G. Britt.; *Leskea recurvans* Rich.; *Raphidostegium recurvans* Jaeg.) Widely cespitose, yellowish green, glossy, complanately branched; scales strongly falcate-secund, dense, imbricated, concave, ovate-lanceolate, filiform-acuminate, narrowly recurved below, basal cells yellow, a few alar cells hyaline; seta ½–1 in. long, sporangium oblong-ovate, inclined, slightly arcuate, strongly so when old; lid conic, beak oblique, ½ the length of the sporangium, neck tapering. Late fall. Wood and soil at the base of trees. Fairfield, Lake.

10. *S. tenuirôstris* (Br. & Sch.) Broth. (*Sematophyllum tenuirostris* E. G. Britt.; *Hypnum cylindrocarpum* C. Muell.; *Raphidiostegium cylindrocarpum* Jaeg.) Flatly cespitose, dense, in wide mats, branches, sparse; scales oblong-lanceolate, narrow, slenderly acuminate, margins recurved, concave; seta ½–¾ in. long, sporangium cylindric, almost or quite erect, brownish, peristome yellow, cilia rudimentary or wanting, lid with an oblique rostrum about one-half the length of the sporangium. Winter. Rotten logs and rocks, usually in hilly or mountainous regions. Champaign, Clark.

19. HETEROPHYLLON Lindb.

Various, paraphyllia large and numerous; scales erect-spreading, non-plicate, basal cells yellow, alar cells inflated, yellow or brownish, sharply differentiated, not falcate or secund.

1. *H. haldanianum* (Grev.) Lindb. (*Hypnum haldanianum* Grev.; *Stereodon haldanianum* Lindb.) Loose mats, brownish-green, irregularly pinnate scales loosely imbricated, stem scales broad, lance-ovate, short acuminate, auricles distinct and concave, bordered by quadrate cells; seta 1½–2 in. long, castaneous, sporangium cylindrical inclined or sub-erect, slightly curved, lid short and sharp rostrate. Autumn and early winter. Earth, rocks, and decaying wood in woods. Fairfield, Lake, Perry.